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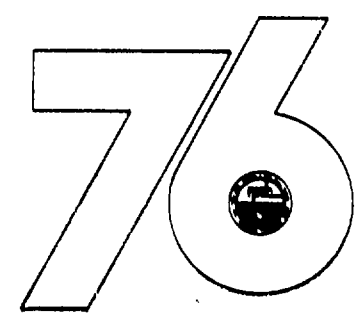
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DESIGN OF TRAINING SYSTEMS  
(DOTS) PROJECT: TEST AND EVALUATION  
OF PHASE II MODELS

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DESIGN OF TRAINING SYSTEMS (DOTS) PROJECT:  
TEST AND EVALUATION OF PHASE II MODELS

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## FOREWORD

The test and evaluation of models developed in Phase II of the Design of Training Systems (DOTS) project was conducted under Advanced Development Objective ZPN07 (formerly P43-03X), entitled "Education and Training Development."

This test and evaluation was possible only through the cooperation of several individuals and organizations. The User T&E group was comprised of CDR Jack Davis and Mr. David Thomas (CNTT), LCDR Thomas Ferrier (COMTRAPAC), Mr. Edward Scheye (CNET), LCDR Bob Biersner (CNETS), and LT Ross Brooks (COMTRALANT). These individuals in particular and their commands in general bore the brunt of providing the necessary information to assess operational feasibility. The Training Analysis and Evaluation Group (TAEG) and the contractor, IBM Federal Systems Division, were exceedingly cooperative throughout the course of the T&E. Mr. William Lindahl (TAEG) performed an indispensable role and was supportive throughout the T&E. Dr. Raymond Willis (University of Minnesota) provided key insights to the technical evaluation of the models and suggestions for alternative statistical approaches (Appendix G).

J. J. CLARKIN  
Commanding Officer



per FL 88 & Form 50  
on file

## SUMMARY

### PROBLEM

An Advanced Development Project titled, Design of Training Systems (DOTS), has attempted to demonstrate the feasibility of applying new decision making technologies, based upon the behavioral and management sciences, to the management of training in the Navy. Several prototype applications were developed using mathematical modeling approaches. It was necessary to independently ascertain whether feasibility had in fact been demonstrated through the prototypes thus far developed.

### OBJECTIVE

A test and evaluation was undertaken in order to determine the technical, operational, and financial feasibility of the prototypes as well as of the broader applications of the technologies in question throughout the Navy Education and Training community.

### APPROACH

Thorough documentation of the preliminary system analysis, model development, and model validation was provided for technical review. The model formulations were analyzed for theoretical soundness, sensitivity to the problem, and validity of problem representation. An operational test and evaluation was conducted to include the following: (1) determination of data availability, validity and reliability, (2) operation of the models using real (current) data, (3) "hands-on" user evaluation of the models by representatives of various Naval Education and Training Command functions and (4) position papers from prospective user commands regarding implementation of the prototypes. A determination of financial feasibility was approached through analysis of the component cost of model usage, projection of model utilization and gross estimators of benefits stemming from the models.

### CONCLUSIONS

The models were determined to be technically sound overall. In certain instances alternative approaches might strike a more effective balance between detail of information, and practicality of operation. The validity of the models was demonstrated with regard to software coding. However, a comprehensive validation must still be accomplished through field testing under operational conditions prior to implementing any of these prototypes. The model prototypes were judged to be operationally and financially feasible for application at the Fleet Training Command level.

The higher order feasibility of applying the technologies represented by the prototypes, throughout the Navy education and training community was positively indicated to the extent possible given financial and temporal constraints of the model development project.

#### RECOMMENDATIONS

Data collection and review for field testing of the System Capabilities/Requirements and Resources (SCRR) and Training Process Flow (TPF) models at the Fleet Training Commands should be initiated. These models should be modified as necessary to operate at the training command level. The ETE model should be given greater exposure to ILS developers in the training community and appropriate field test for that model should be arranged (pp. 57ff).

Since it appears that any one model or system of models would be insufficient to comprehensively address present and future Navy training management problems, a continuing capability to apply the kinds of technologies reflected by the DOTS prototypes should reside within CNET (pp. 57ff).

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## INTRODUCTION

### PROBLEM

The Design of Training Systems (DOTS) project has attempted to demonstrate the feasibility of introducing new technologies of education, psychology, management, and operations research to the management of Navy training. Several prototype applications were developed using mathematical modeling approaches. Three of these prototypes were selected for further development. The technical, operational, and economic feasibility of these models must be determined.

### OBJECTIVE

The primary objective of the test and evaluation reported herein was to determine the technical, operational, and financial feasibility of the selected prototypes. A second objective was to determine the broader applications of the technologies in question throughout the Navy education and training community.

### BACKGROUND

The DOTS project is Part 01A of the Technical Development Plan (TDP) for Advanced Development Objective (ADO) ZPN07 (Education and Training Development). The Principal Development Agency for this ADO is the Navy Personnel Research and Development Center (NAVPERSRANDCEN). The DOTS project has been managed by the Training Analysis and Evaluation Group (TAEG), and the principal model development has been performed by a contractor, IBM Federal Systems Division.

The DOTS project took a three-phased form. Phase I consisted of a systems analysis of the Naval Education and Training System. This phase resulted in (1) a descriptive functional model of that system, (2) a set of strategic assumptions concerning that system in the 1980 time frame, and (3) the identification of a number of candidate computer-based mathematical model types which could support Navy training management.

Phase II consisted of the selection, development, and validation of three of these model types, as well as development of a support data base. The three models selected were (1) the System Capabilities/Requirements and Resources (SCRR) Model, (2) the Training Process Flow (TPF) Model, and (3) the Educational Technology Evaluation (ETE) Model. These models were subsequently formulated and validated by the contractor.

Phase III consisted of further validation and verification of the models. The DOTS TDP explicitly called for an independent test and evaluation of the Phase II models (see Appendix A). NAVPERSRANDCEN was charged with the responsibility of conducting this T&E, with assistance to be provided by representatives from the Chief of Naval Education and Training (CNET) and its functional commands (see Appendix B).

For further background information on the DOTS project, see TAEG Reports 11-1, Summary Report, of December 1973 and 21-2, Volume I, Phase II Overview, of December 1974.

## ON-SITE USER TEST AND EVALUATION

### General

The on-site test and evaluation (T&E) was conducted at the Fleet Training Center (FLETRACEN), Norfolk, Virginia during the period from 23 to 27 June 1975. The initial T&E plan formulated and distributed by NAVPERSRANDCEN (Appendix C) established a User Evaluation Team comprised of representatives of CNET and its functional commands. The primary responsibility of the User Evaluation Team was to develop a comprehensive statement of evaluation focussing on the operational aspects of the Phase II models. NAVPERSRANDCEN was to coordinate this user evaluation and take primary responsibility for technical and economic assessment of the models.

### Technical Feasibility Assessment

A thorough technical review was made of the documentation on the preliminary system analysis (Phase I) and model application, selection, formulation, and validation (Phase II). The model formulations were analyzed for theoretical soundness, sensitivity to the problem, and validity of problem presentation. Consideration was given to (1) the relationship between the kinds of information produced by the model and the information needed by management in the real world, (2) the manner in which the information is developed within the models, and (3) the data upon which model values are based. Although NAVPERSRANDCEN was primarily responsible for this review, inputs were provided by members of the User Evaluation Team. Results are presented in the following section.

### Operational Feasibility Assessment

#### On-site User Evaluation

A model evaluation framework was formulated and distributed by NAVPERSRANDCEN to User Evaluation Team members (Appendix D). The assessment of the operational feasibility of the Phase II models was to be approached by holding discussions on the following five major areas: (1) potential model contributions, (2) ease and practicality of use, (3) data requirements, (4) organizational implementation, and (5) user investment. These discussions were held during the first 3 days of the User T&E. During the first session, i.e., on potential model contributions, team members were provided with a number of command level problem areas identified by FLETRACEN personnel and a set of criteria with which to evaluate these problem areas (Appendix E). During the last 2 days of the User T&E, team members developed a comprehensive evaluation statement covering the results of the discussions. This statement is presented in a later section. Although the text of this statement was reviewed by all representatives, divergent opinions in some areas are still evident. Along with the evaluation statement, team members developed a number of conclusions and recommended that CNET function representatives meet again to finalize the T&E.

### User T&E Followup Meeting

In response to the User T&E Team recommendation for a second and final meeting, the representatives were again contacted (via phone) in August. Each of the representatives had an opportunity to present the DOTS models and user evaluation to their respective commands. It was hoped that through this process a broader feedback from potential DOTS users could be fed into the T&E. It was also thought that, given general acceptability of the models, the potential user organizations might provide an explicit account of their position vis a vis the models. This would, of course, greatly facilitate follow-on development or complementation of the DOTS products.

The need for a second user meeting seemed far less pressing after these discussions. For the most part, the positions of the various representatives had crystalized as a result of discussions within their commands. The representatives from CNETS and CNET had much less of a basis for providing additional feedback since their organizations would not be immediate consumers of the models. The other representatives either were in the process of completing written command position statements or had already done so. It appeared that an additional meeting with the former two representatives was unnecessary; whereas, individual meeting with the latter representatives promised to be more fruitful\* than another joint meeting.

Consequently, the CNET and CNETS representatives forwarded statements of position along with copies of the User T&E report with further comments and editorial changes (see Appendix F). Separate face-to-face meetings were arranged with the TRAPAC, TRALANT, and CNTT Representatives. As a result of these meetings, briefings on the DOTS T&E were provided to RADM Hill, RADM Gibbons, and RADM Sackett, respectively. (RADM Sackett and his staff were also given a demonstration of the DOTS models by IBM). In addition, written position papers concerning DOTS were obtained from each of the commands (See Appendix F).

### Fleet Training Command Evaluation

A final phase of the user followup took place at COMTRAPAC in September. Throughout the T&E there had been a dearth of feedback as to FTC, Norfolk reactions to the specific utility of the various model information products, though some general reactions had been provided by the FTC DOT and the TRALANT T&E representative. It was determined that while the FTC application was not a field test per se, the level of model development and opportunity for application was such that specific examples of model utility using actual (if historical) problems, along with FTC management reactions, should have been produced in the course of DOTS Phase III. The potential model contribution questions (Appendix E) were an attempt to approach

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\*"Fruitful" in the sense that, these being the most likely immediate users of the models, prospects for specific implementation could be more easily and comprehensively addressed. Furthermore, there was no requirement for a team consensus of opinion.

this level of specificity. But a more direct assessment still seemed necessary. Furthermore, some questions concerning ease of use of the models and supporting documentation still remained unanswered as a result of the on-site User T&E.

Consequently, an additional user test and evaluation was arranged at CONTRAPAC. This was a small scale effort directly involving only the CONTRAPAC and CONTRALANT T&E representatives as well as some local support personnel. These two training managers were provided with a pool of sample model problems which they could modify or draw from as they saw fit in order to properly assess the value of model outputs. Since there were to be no IBM, TAEG or NPRDC personnel present during the assessment, it was also considered a good test of the models' ease of use, given their current level of conversational programming and supporting documentation. In sum, it was thought that this assessment would provide an indicator of how close the models were to being implementable techniques at a different training complex which possesses similar environment and composition to the development site at Norfolk.

Two problems were immediately encountered in this assessment. The first was that of equipment compatibility. The training management center at CONTRAPAC presently has a communicating terminal of a different type than that used at Norfolk. Certain settings and adjustments were required through the time sharing vendor before the equipment could be made to function properly in response to the time sharing system. A second problem was that the available model documentation generally proved inadequate for this group of users. The main problem was the absence of information through which to interpret error messages and to rectify incorrect responses.\*

This situation largely prohibited using the models to address a number of real training management problems that arose during the course of this assessment. For example, there had been a congressionally based inquiry as to the probable impact of doubling the proportion of student AOB to instructors and supporting staff. This could have been a fine application of DOTS model capability.\*\*

Adjustments were made so that by the conclusion of the assessment period, the models were completely functioning on CONTRAPAC's equipment. Thus it has been demonstrated that the models in their current form can be accessed by CONTRAPAC. Furthermore, since CONTRAPAC presently has provided computer terminal capability to both schoolhouse and staff levels, it can be seen that the way is well paved for field testing and implementation of the models at that command. Also, a keen interest from TRAPAC school administrators in applications of management science techniques to their problems was reported. This complemented the general interest of TRAPAC in the MIS capabilities of the DOTS data base and

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\*It should be pointed out that at this time, IBM was at work on further user documentation that would offer greater support of this type.

\*\*Of course, even if the models had been used, the answer would have only been a sample one since the present model data base only represents FIC, Norfolk.

improvements that it makes on present NITRAS capabilities. For example, NITRAS does not presently contain facilities information. Thus TRAPAC is unable to use it or address facilities plans in connection with the Program Objectives Memorandum (POM) process.

#### Comments on User T&E

It is fairly obvious from the above account that a preponderance of consideration was given to operational feasibility and user relevance throughout the T&E. This was intentional since it became apparent, after an initial review of DOTS, that organizational implementation was the pivotal issue in the DOTS feasibility test. Any difficulties in overcoming technical problems in modeling this particular organizational environment are dwarfed by problems that could arise in actual implementation of such models, even if they were technically precise in their representation.

The documented user evaluation and subsequent position papers (Appendix F) speak for themselves and their directness would perhaps only be clouded by further elaboration and interpretation here. Nor would it be appropriate to address or rebut in detail exceptions that were taken with the model development phase (e.g., by CNET in Appendix F). This is more fittingly a task falling to the model developers and project directors. Rather, the comments below are intended to put the various user comments into perspective so that a clearer image of user feedback is provided for the purpose of test and evaluation.

Taken as a whole, the on-site User T&E indicated a high level of consumer receptivity to the models and their underlying rationale. Here the models were viewed primarily in terms of what they could contribute to FTC, Norfolk, and in a greater sense, to COMTRALANT. Then the models were also viewed in terms of how well they would transfer to similar training complexes elsewhere in EDTRACOM. The possibility of applying the models within COMTRAPAC, with a minimum of modification, was generally seen. To a lesser extent the models were viewed as a system which might be administered from the CNET throughout EDTRACOM. It is doubtful that if the latter viewpoint predominated, such a positive evaluation would have been rendered by the users.

CNTT's final position (Appendix F) expressed a negative view of DOTS. The CNTT comments must be given attention in view of the fact that the technical training command contains the largest proportion of potential uses of DOTS type products.

The strictly technical objections raised by CNTT are addressed in the Management Summary in a later section. These considerations are technically superficial and may have, in turn, stemmed from superficial explanation of these features at the on-site T&E. A more general point was made that the FTC development site was unrepresentative of the critical training management problems and was a poor choice. Consequently, proof of feasibility was not seen since the present level of organizational application is not cost effective. This issue is exceedingly relevant to the purpose of the T&E. It can be dealt with only through the

realization that FTC, Norfolk was not the perfect site but that it does have the characteristics that were necessary and sufficient to establish the feasibility of the modeling approach beyond a reasonable doubt. At a minimum, this feasibility was established to a point where it appears worthwhile to proceed to a rigorous field test which can dispel any residual doubt.

It was essential that the models produced in Phases II and III address the schoolhouse level since this is the basic building block of the EDTRACOM. Without showing a basic capability to deal with the dynamics of this level, the demonstrated feasibility would have been extremely weak. Yet, as CNTT has pointed out, this level is not where the major payoffs are to be gained. There is little doubt that it would have been much better to have also had a demonstration of modeling applicability at a higher management level (e.g., the TRACOMS). A field test of the applicability of the TPF and SCRR models at such a level is recommended as a result of the T&E.

The present management level residence of the model is just one of many reasons that there are not numerous examples of actual model use at FTC, Norfolk. Turnover, training time, time needed to gain management acceptance through experience, hesitancy of model developers to trigger defensive reactions from FTC staff (i.e., by showing virtue of potential cuts), and the lack of a well defined model interface position (person) all contributed to the low usage level. It is significant to note that during the follow-up evaluation at COMTRAPAC (see preceding section), a number of real world problems arose toward which the models could have been effectively directed, if TRAPAC data had been compiled.

The structures of the models, including even the ETE, are such that there are no major conceptual problems apparent in adapting them to TRACOM level use. It is expected that this level of application will show high utility for the model products. Just how much of this utility can be transferred to similar functions within CNTT cannot be determined on the basis of present information. It is clear that an unwilling user would prohibit any such transfer.

It cannot be helped but be perceived that a great deal of the negative CNTT reaction is in consideration of DOTS as a "system" and not as a sample of tools from a certain branch of management study. The "system" idea is not a mirage since there are presentations relevant to this point (e.g., TAEG Report No. 12-2, Vol. I, Phase II Overview, pp IV-15 through IV-19). One can only agree with CNTT that a system "for all levels of management" is far beyond the scope of what has been demonstrated thus far (Appendix F, p. F-17, para. 3). It is not believed that CNTT would be so quick to reject the models as tools rather than the primitive form of a total management system.

While application of the models within CNTT proper seems unlikely at present, COMTRAPAC emerges as a desirable, ready, willing and able field test and implementation site for the following reasons: (1) favorable disposition of the command towards the models, (2) a strong current need for improved MIS capabilities and a growing need for supportive decision-making tools, (3) present access to all necessary terminal equipment

throughout the command, (4) general familiarity with ADP applications and close working relationship with DPSCPAC, (5) existence of individuals/positions who can serve as effective model interface points for managers as they become familiar with the model capabilities, and (6) the opportunity presented to test and implement the models at a higher management level.

#### Financial Feasibility Assessment

The financial feasibility of the DOTS models was addressed by the model developers (TAEG Report 12-2, Section IV). Obviously, two factors are pertinent here, first the cost of formulating, operating and maintaining and second, the benefits to be derived. These factors must be considered in the light of the scale of operations (e.g., how many sites), existing equipment, existing data, opportunity/frequency of model use, and future plans for the EDTRACOM.

Given that the models necessitated the acquisition of a computer main frame, it would be necessary to project model usage beyond one site in order to offset the initial fixed investment.\* The bulk of the model developer's financial analysis is thus aimed at a strategy for projected model usage. The results of Phases II and III in no way warrant the usage assumptions made in that analysis. As a consequence, the resulting cost-benefit conclusions are not viewed as acceptable.

In the light of the ubiquitous time-sharing resources of today and the competitive pricing of those services, software such as the DOTS models can be viewed to a large extent as independent from supporting main frames. This permits the cost-benefit analysis to be reduced to the more concrete parameters of the model development site and its immediate extensions. Generalizations can then be made to other potential sites which would use either the current models or other models to be developed in the future. (The latter case would also involve development cost.)

As a result of discussions with members of the User T&E team and visits to various EDTRACOM sites, it can be validly assumed that utilization of computer-based models like those of the DOTS project will not require special data or equipment acquisitions of a significant nature.\*\* From this it can also be assumed that the basic skills needed to operate the models will also be present at most sites. Since model operation and data maintenance which does not replace existing procedures is estimated to consume a very small number of man-hours, it is not anticipated that support personnel cost will be appreciable. There will be a training cost. On the basis of training conducted prior to the on-site User T&E, this is

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\*That is, given the nature of models, it would be extremely unusual for even a group of them to justify the cost of a dedicated main frame.

\*\*The facts that the models primarily draw on data presently being collected and that necessary hardware has either been acquired or soon will be, regardless of the models, have been discussed earlier.

estimated at about four man-weeks per site (2-4K). Data pertaining to time-sharing cost for the models were obtained from actual model operation at FTC, Norfolk (see TAEG Report 30 May 1975, Users Test Guide, section V). Using these cost data and a somewhat arbitrary estimate of the extent of usage, an estimate of \$10K per year was obtained (using all three models). With some amortization of training cost, this results in a total yearly cost that can be safely estimated at under \$15K, allowing for some equipment depreciation (or rental cost allocation) and model maintenance.

On the benefit side, perhaps the most meaningful indicator revealed in the T&E was provided by comments from the User T&E team that the modeling and MIS capabilities demonstrated by DOTS would be worth at least two billets at the training center level of implementation. As the technical feasibility section of this report pointed out, a field test is necessary to precisely identify a measure of benefit. However, the costs as estimated above are low enough to make application of the models a low risk proposition, especially at the TRACOM level.

The greater question of financial feasibility concerns to what extent the results of DOTS can be extrapolated to assess the feasibility of applying such management techniques throughout the EDTRACOM in general. Since the techniques employed by the DOTS models (e.g., LP, simulation) are a fair sample of the field from which they are drawn, it seems reasonable to generalize the order of operating costs estimated above. The quality of benefit analysis thus far possible, in no way warrants similar generalization. However, a plus factor for products such as the DOTS models is the current state of management information systems (MIS) within the EDTRACOM. These are currently emergent and embryonic. Since the models are very complementary to the MIS development process, a fairly consistent MIS benefit might be projected from one development site to another. This underlying benefit might be capable of covering most risks associated with the more sophisticated utilities of models.

Development cost must also be computed into the generalized feasibility assessment. The costs incurred to develop the DOTS models appear inordinate and probably not supportable at anything less than command level implementation. But those costs included many one-time items necessary to initiation of the project. It is believed that development cost could be brought to a reasonable level if a small, in-house modeling capability was pursued by CNET, using contractor support only for very specific and definable end products. In this way (1) maximum transfer of learning could be made from one site to another, (2) the sizeable initial cost of becoming acquainted with the EDTRACOM environment would not be repetitive, and (3) a closer and more continuous user/model developer relationship could evolve. This procedure would minimize many of the large cost items associated with model development, maximize many of the factors which contribute to effective modeling, and in general take advantage of the large capital base presented by the EDTRACOM.

### Final Statement of User Evaluation

At the conclusion of the User T&E, NAVPERSRANDCEN prepared a final statement of user evaluation. This management summary, which includes recommendations for the conclusion of DOTS and for a future program resulting from DOTS, is presented as the last section of this report.

## RESULTS OF TECHNICAL REVIEW OF TECHNICAL FEASIBILITY

### System Capabilities/Requirements and Resources Model (SCRR)

The SCRR is a linear programming (LP) model which utilizes a standard software package, Mathematical Programming System Extended (MPSX, an IBM product). It deals primarily with instructor and classroom resources as related to demand (courses, class input capacity). The SCRR was developed to meet four specific types of management problems. These are discussed below.

#### 1. Assessment of long-term training demand

This title could be a bit misleading. It should be clear that the SCRR is not a predictive or probabilistic type model. What it can do is take near or long-term training demand projections as input, and then operate to determine whether such requirements can be feasibly met given current or projected resources and procedures. In this sense, given sufficient lead time, it can aid in training resource planning and capabilities assessment.

The utility of the model, however, does not depend entirely upon a prerequisite, accurate demand forecast. The model could be run in a planning mode under a number of different demand assumptions. A range of training capabilities and resultant impacts could thus be assessed. These would only support management contingency planning, however, and would in no way constitute demand forecasts per se.

Another product of the SCRR relevant to this aspect is the "optimized convening rate." This is the number of course convenings per course that yields maximum student throughput. (This is a result of one of the LP's two basic modes of operation - the other being the determination of minimum resources given fixed convenings.) This Optimal Convening Rate would seem to have very limited utility. It denotes maximum possible output only under assumption that all students are of equal value. It also implies a free market type environment and one in which demand for any given student is always in excess of supply. It is true that a weighting scheme, if extant, could be easily input to the model thereby yielding a meaningful output in terms of a maximum. But the determination of how to arrive at such weightings with appropriate consideration of multi-level training system objectives is a study in and of itself and one for which the basic data probably are not presently available.

2. Assessment of short-term demand fluctuation arising from unscheduled events (e.g., a Ship repair operation, reserve activation, unusual seasonal recruitment levels).

Here different resource and demand configurations can be "tried out" to assess the impact of such perturbations - minimizing their dysfunctional effects and maximizing the responsiveness of training - through better allocation of available resources. This usage seems quite desirable given the existence of frequent perturbations in demand. Limited usage at FTC, Norfolk seems to indicate that a rather minimal level of model analysis can yield information of broad and recurring utility to the training manager. Yet usage of the models by managers seems to need at least initial stimulation.

3. Assessment of training resource utilization

Using current demand, SCRR can compute an optimum resource combination. The resulting utilization rates may be contrasted with current utilization. This is an intuitively attractive feature of the model. There appear to be potential problems in interpretation and ultimately, actual use of this information. The utilization rate is presently in terms of hours available for instruction. The instructor staff at the schoolhouse has other non-instructional duties, however. For some instructors, these duties may comprise a considerable portion of their total work days.

4. Comparison of alternative resource allocation strategies

This is a use of the model in which multiple strategies are evaluated, given known performance and requirements characteristics. This is one of the best uses of the linear programming capabilities of the models and could precipitate substantive changes in present procedures for developing plans and programs as well as justifying and revising the same.

Model Selection

The decision to develop an LP model to assess capabilities and to allocate resources in the training environment was sound. The relationships of students to instructors and students to facilities have traditionally been linear--although in a stepwise way. Thus, the constant returns to scale assumption of the basic LP model fits well into the resource management framework of Navy training.

\*A mixed integer formulation, while apparently not necessary in this application, is entirely within the scope of this type of model.

The information - rich properties of the LP output provide a fine opportunity to evaluate potential model contributions in a new area of application. The fundamental LP problem characteristics of proportionality, additivity, non-negativity, divisibility, and deterministic model coefficients are adhered to by this application.

#### Model Formulation

The model is formulated to deal with variables of the following types:

course variables:   length  
                          capacity  
                          convening frequency  
                          instructor requirements  
                          classroom requirements  
                          lab requirements  
                          equipment requirements

instructor variables:   qualifications  
                          assignments  
                          availability  
                          rotation date

facilities (class and/or Lab)  
variables:                   location  
                              capacity  
                              availability  
                              course assignment

The objective function is to maximize student throughput (i.e., number of students trained per model run), subject to a variety of requirements constraints related to the variables listed above (e.g., class # XXX must be convened Y times each year). A continuous relationship among the model parameters is assumed (i.e., the problem is not formulated as an integer program).

The model is well formulated from the standpoint of the variables considered, logical representation of those variables, level of detail, and type of information produced. The overall worth of the model, however, rests very heavily upon the validity of the "planning factors" which it incorporates (e.g., number of hours instructors are available for training, student - instructor ratio). In addition, certain needs to segmentize the problem within the LP formulation result in a

much less sensitive model than might be expected. The resources and requirements of one school are treated as independent from those of another in this model framework. This appears to be somewhat less realistic a portrayal with respect to facilities than to instructors. (i. e., Lectures do not normally require specialized classrooms, regardless of subject matter; instructor qualifications, on the other hand, can lead to considerable specialization and hence, independence from one school to another.) Finally, another problem lies in the interpretation of the primary objective function (i. e., max student thrupt) and of resulting information products (i. e., instructor utilization). Each of these points is discussed more fully below.

The issue of the validity of using the planning factors incorporated into the SCRR is a difficult one. In the classic applications of LP, the requirement constraints are explicit and unquestioned (e. g., the basic formulas used in a chemical production process).<sup>\*</sup> This validity carries directly over to the results of the LP model of such a process. However, when the process being modeled is very much dependent upon human resources, precise requirement formulas are usually unavailable. In this environment the question of requirements is usually a very prominent one. Any misconceptions that a "requirement" model introduced to this environment provides better basic requirements information than previously available, must be carefully avoided.<sup>\*\*</sup> Yet, in the particular case of the SCRR, there is little doubt that modeling has demonstrated the potential for increasing the quality of management information at the FTC as well as for the functional command level above it.

The manner in which this has been done is well illustrated by the parametric analysis performed on the impact of instructor availability (TAEG Report 12-2, Vol II, pp II-54 - 60). There presently is no firm standard for instructor available hours at the FTC. A standard of 1000 hours per year per instructor was initially used. This figure is very important, obviously, since it determines feasibility and utilization of resources. While the model can offer no improvement in the identification of instructor availability, it can

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<sup>\*</sup>See Charnes, A. and Cooper, W. W. Management Models and Industrial Applications of Linear Programming, (Vols. I and II), Wiley 1961

<sup>\*\*</sup> It is not even correct to take the position that since "soft" planning factors are being used anyway, a model that incorporates such factors can do no worse than current procedures. Planning factors heuristically utilized by managers are quite different in effect from those which lie within the aura of a computer model.

be used to show what would be the effect of different availabilities on the training complex. (It was shown that, ceteris parabus, availabilities of 700 hours or 900 hours could not meet convening requirements.) Similar analyses can be performed to illustrate the effects of changing student-instructor ratios, class capacities, instructor qualifications, etc.\*

The segmentation of resources and requirements within the SCRR limits its ability to optimize across the training center. While this convention enables most candidate FTC problems to be fit within reasonable computer storage limitations, it appears to be a less than accurate representation of what is possible within the real training environment. It may be that some of the greatest management payoffs within the FTC are to be gained from optimizing resources and requirements across schools. This type of analysis could be approached to some degree with the model as currently formulated (given some recoding and restructuring of data). Future model modifications could permit it to be performed on a broader scale.

The objective function of maximizing student thruput is less intuitive than one which minimizes resources for a given demand. (The latter is possible within the SCRR but is given less emphasis in the documentation.) Both types suffer from the inability to discriminate the value of one student versus another. Thus the optimization is biased towards shorter courses and courses which are resources rich (i. e., a student is a student). Utilization rates produced by the SCRR are difficult for users to interpret. Aside from the basic consideration of what to put in the denominator of the utilization index (i. e., the availability question described above), one is hard put to interpret the figures in the "good-bad" framework that managers seek. For example, an increase in the number of course convenings will increase resource utilization but could decrease course utilization (in actuality). Also, any utilization figure must be interpreted by the user with due consideration for available time consumed by supervisory duties, military duties, preparation for instruction, etc.. These are factors not considered by the SCRR at present.

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\*A fault of the Phase III documentation is that such applications are described as possible yet only the instructor availability analysis is actually documented for evaluation. The old saw of a picture being worth a thousand words definitely applies here. An analysis is supposedly conducted on effects of instructor cross training is not documented for evaluation at all.

### Model Validation

The basic linear programming technology and the MPSX software are, of course, not in need of validation due to their standardized nature. The validation documented by the model developer (TAEG Report 12-2, Vol II, pp II-30 - 60) demonstrate that the model is functioning properly. The model's ability to accurately represent the real world is not demonstrated. This must be done with historical data or under field test conditions. In the absence of such information, the SCRR is judged to be a useful and practical representation of the training complex.\*

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\*This judgement is a function of (1) feedback from prospective users obtained in the user T&E and other discussions (2) a comparison of the model's formulation with a description of the training complex operation.

### Training Process Flow Model (TPF)

The objective of the TPF is to provide a means for simulating the flow of students through a training complex. This simulation is intended to enable managers to assess the effects of changes in the primary variables of the training complex and its immediate environment. The model operates on two categories of data, those pertaining to students (10) and those pertaining to courses (15). Given inputs such as maximum or average course capacity, number of convenings, and demand, the TPF computes course utilization, backlog, AOB, etc., showing these on a quarterly bases through time.

The variables currently dealt with by the TPF have been screened from a larger set of variables on the basis of statistical analyses. An original objective of the TPF was to develop statistical parameters from these analyses which could be included in the model for the purpose of predicting training results as a function of student profile data. Correlations resulting from these statistical analyses were not of sufficient significance to warrant inclusion in the model and therefore were not incorporated. Straightforward proportionality figures are currently used by the TPF to assess the effects upon the training system of changes in demand, scheduling, or capacities. Failure rate, no-shows, disenrollments, etc., are not presently forecasted by the model on the basis of student profile data. Thus the TPF, as a simulation, mathematically represents the mechanics of the training center scheduling function from a deterministic rather than probabilistic basis.

#### Model Selection

The choice of a process flow model was a good, if perhaps obvious, selection (and as such did not depend greatly on the results of Phase I). The course scheduling problem is one which both lends itself to modeling and at the same time represents a significant training management problem. The flow also offers a complementary capability to the resource allocation model (SCRR) that was concurrently developed.

The magnitude of original potential payoff from this model is substantially reduced as a result of its present inability to statistically relate student profile data to student behavior within the training system and the consequent inability to gauge the potential impact of such factors (see below).

Another restrictive factor is the apparently limited opportunity which training managers at the FTC level have to utilize such a model in a proactive manner. This mostly stems from the fact that fleet training demands are at the same time hard to predict and hard to deny. On the other hand, the more reactive capabilities of the model (e.g., to answer "what if" questions) do not appear to be in high demand at the FTC level, though they may be periodically of substantial value to that level. It is important in considering this to keep in mind the DOTS models were selected on the basis demonstrating the feasibility of an approach for CNET and not on the basis of what models/techniques would yield the highest payoff to FTC, Norfolk in particular.

In contrast to the time/flow orientation of the TPF, the SCRR offers more of a snapshot assessment of the capabilities and requirements of the training system at a given point in time. It adds the considerations of facility and instructor resources to the problem of "How many classes of what size can be convened?". These considerations form a necessary complement to the TPF. In fact answers from either model would be partially naive without those of the other. This prompts the question of why select and separately develop two models, neither of which is sufficient by itself, rather than develop one integrated model from the beginning. The answer to this question, I believe, lies in the initial orientation of the project - it has been technology oriented rather than problem oriented (i.e., "test the feasibility of applying new decision making technologies"). Developing two separate models provided a more secure approach to that problem. Furthermore the original concept of the TPF (i.e., to forecast training complex impact as a function of student profile data) lent it more viability as a separate model concept.

Given the present lack of statistical relationships with student data, present functions of the TPF may have been more easily carried out by selecting some other type of approach such as using a data base management package. Nevertheless, much of the same analysis that was required to formulate the TPF would similarly have been required.

#### Model Formulation

The TPF is formulated so as to simulate on a week by week basis. Provision is made for holidays. Since a course can only be directly shown as convening a maximum of 50 times (one per week) in this manner, duplicate courses are created within the scheduling algorithm in order to handle convenings in excess of that number.

Based on the technical information presented, it appears that an alternative formulation might be more direct. The need for "week by week" information was not apparent from either the DOTS documentation or feedback from users at FTC. Given this, the basic scheduling dynamics of the FTC that were derived from the training process analysis, could have been represented in the model as a vector that could be transformed by various conditional data to yield output on a quarterly basis. (i. e., There is no compelling reason to maintain the "week by week" level of detail - especially if it demands more complex programming and data manipulation.)

Though the TPF does not currently simulate on the basis of student profile data and the results of the statistical analysis of that kind of data are not incorporated into the model, some comments are warranted. First, the idea of formulating a model to predict impact on the training process from various types of student inputs remains intuitively desirable. Users participating in the on-site T&E indicated that large payoffs could result from such an ability. Furthermore, while the DOTS statistical analysis failed to uncover correlations of sufficient significance to warrant inclusion in the TPF, the conduct of that analysis does not support a conclusion that such correlations are not to be obtained.

A statistical analysis such as that used in the course of developing the TPF, should be preceded by the development of a conceptual model (reduced to mathematical form) which states the relationships that are hypothesized to exist. The danger of proceeding without such a model are many. Examples can be seen in the tables of results documented from the DOTS analyses (e.g., TAEG Report 12-2, Vol III, p. 63). Another manifestation is in the representation of failure in the regression model. The statistical analysis used data which described failure as a 0,1 variable. This in itself is a violation of assumptions underlying the use of regression in the first place.\* A second point is that the model is constructed from an individual standpoint; the dependent variable is "did the student pass or fail," the independent variables being that student's GCT and ARI scores and the number of schools previously attended. Yet the resulting model is used to predict a group failure rate on the basis of average GCT,

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\*See, for example, Neter, John and Maynes, E.S., "On the appropriateness of the correlation coefficient with 0,1 dependent variable." Journal of the American Statistical Association, June 1970, Vol 65, No 330, pp 501-509.

ARI, and number of schools for the group. This is an inappropriate use of the coefficients derived from the regression analysis performed to construct the model. Finally, it deserves to be pointed out that if the objective was to predict group failure rates, a number of other variables should have been included in the analysis (e. g., instructor variables, group mix, class size, etc.).\*

#### Model Validation

The validation procedures for the TPF, as described by the model developer (TAEG Report 12-2, Vol II, IV, pp. 22-30) do not constitute a true validation. The model is simply exercised in a number of conditions and its deterministic processes are allowed to respond accordingly. It is clearly demonstrated that the model is in operating order. However, there is no basis for judging how well the model simulates the real training process flow. All that can be said is that the factors utilized in the TPF appear to be reasonable since they are drawn from those which are commonly used by the training managers.

Of course, a true validation would have entailed the use of historical conditions and the matching of model output to actual outcomes in the training environment resulting from those conditions. There appears to have been no attempt at such a procedure. (Of course, this would be more of a validation of the planning factors used by the model than of the mechanics of the model per se.) Thus we know that the TPF is a useful automated version of the kind of scheduling that is presently being carried out at the FTC. We have a more flexible and quick means for developing schedules and assessing demand impacts. It has not been demonstrated that we have a more precise or accurate means for making such developments or assessments.

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\* For more elaboration of these points, see Appendix G

## Educational Technology Evaluation Model (ETE)

The ETE is an entity flow simulation model for ILS course design and management. Like the TPF and SCRR, this model is intended to answer questions concerning capabilities (capacity), utilization, and resource requirements as well as course completion time. It has the capability to evaluate, in compressed time, the effects of real or projected changes in resources or demand. Since equipment and personnel can be costed external to the model, the model can be used in making cost-effectiveness determinations of different ILS course designs.

The ETE is a general purpose simulation model and is thus not structured around a specific type of course. Its data base would not normally even approach the complexity of that of the TPF and SCRR. The data for a typical model run can be entered by the user at the start of a model session (and then stored for later recall or modification). Theoretically, the ETE could at present be applied to any ILS course or group of courses, regardless of location or even if the course is yet to be convened.

Of course, the ETE must work from basic requirements information just like most models. For example, the user has to input the number of hours of instructor time needed for x number of students, the average time required by a student on a certain module, the arrival rate of students (i.e., demand) etc.

### Model Selection

Factors favoring the development of this model included: (1) increasing numbers of ILS courses throughout EDTRACOM, (2) increasing resource constraints, (3) existence of previous work in simulating ILS in the Navy, (4) prospects for a general purpose model that could be put to use immediately throughout EDTRACOM, and (5) emphasis of other models on training process, as opposed to course design.

### Model Formulation

The ETE makes use of a standard IBM programming product called General Purpose Simulation System (GPSSV). This is a widely recognized and utilized simulation scheme. The model presents a good adaption of the ILS environment to the simulation framework. All of the major ILS decision variables can be represented and considerable user flexibility is provided. The ETE is generally formulated so that the user can formulate a specific

model to represent a given ILS. The estimated time for such formulation (3-5 days) is acceptable. (See TAEG Report 12-2, Vol II, pp III-26, 31.)

#### Model Validation

In the absence of ILS at FTC Norfolk, the ETE was validated on the basis of a proposed consolidated EW school at Corry Station. The validation was not in terms of how well the ETE simulation represented actual course behavior, but rather to the extent that results replicated those obtained from the application of a previously developed special purpose simulation model of the EW school.

This procedure offers certain advantages (e.g., the opportunity to obtain indicators of both model generality and sensitivity). It has other rather strong disadvantages (e.g., insulation from a "real world" comparison, anchoring to another model of undefined validity and fidelity, absence of user based utility information). Aside from the variability analysis which is acceptable (TAEG Report 12-2, Vol II, p III-24), it is only known that the ETE is as good as or better than another simulation model as applied to the EW school use. Nor does this validation procedure establish the generality of the ETE as implied by the model developer (TAEG Report 12-2, Vol II, pp 23-24).\*

As a result, the ETE remains for the most part, in an unvalidated state. It may be that, as the model developer states, there are no NAVEDTRACOM ILS applications that are presently suitable for use in validation. If this is still true, the condition should not prevail for long. The ETE should be validated against a number of different actual ILS cases as soon as possible.

With the exception of the model validation procedure (which may have been a necessity), the ETE appears to have been soundly developed from a technical viewpoint. However, this technical soundness is as of yet, not bulwarked by a clearly demonstrated utility (i.e., a utility determination arrived at through interaction with actual ILS designers and managers).

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\* Since the basis of comparison is a "special purpose, ad hoc model" in the first place.

### General Comments on Validation Procedures Utilized in Phase III and the T&E

In general, the quality of the validation procedures for the DOTS models conducted during both model development and the T&E, suffers from the lack of a legitimate field test. Consequently, an issue for the T&E is whether or not a field test should have been conducted in Phase III. It is the judgement of this T&E that such a field test could not have been comprehensively performed in Phase III for the following reasons: (1) The models' internal logic and programming were still being tested, (2) Users had not had time to become intimately familiar with the models' capabilities, (3) Data management capabilities and supportive terminal equipment at the FTC, as well as elsewhere in the EDTRACOM were at an embryonic stage (these capabilities are prerequisite to effective model usage), and (4) The models had yet to be evaluated by potential users for general reasonableness and acceptability. (It would not have been possible to obtain the user commitment necessary for proper field testing without first being able to demonstrate that the models were in working order, that they could be made to operate in the training environment, and that they addressed substantive training issues in a useful and meaningful manner.)\*

Present conditions for field testing of the SCRR and TPF appear to be very good at both the CONTRALANT and CONTRAPAC sites. Furthermore, prospects for usable end products emerging from such testing are sizable. This field testing should, at a minimum, fill in some of the blanks left from this T&E evaluation regarding more precise estimates of cost, accuracy, and utility. A suitable field test site for the ETE model is not so evident, but must be pursued. It would not be wise to put that model on the shelf and wait for 1980 to happen.

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\*These conditions did not rule out validity testing using historical data. Unfortunately, the historical data available would not have been complete enough to allow even this type of testing.

## USER TEAM EVALUATION OF OPERATIONAL FEASIBILITY

### Potential Model Contributions (First Discussion Area)\*

General areas of model contribution were noted as follows:

1. Assessment of current training organizations
2. Monitoring ongoing training activities
3. Evaluating possible effects of changes in existing training systems

In addition to more effective performance of the training management function as currently practiced, the models have the potential for introducing new management techniques and supporting certain types of decision making not currently practiced. The DOTS developments are seen as contributing in two distinct but interdependent modes. First, as a management information system by virtue of the data base management capabilities developed to support the models. This was not a direct objective of DOTS but was a prerequisite to producing models which can effectively function in the operational environment. Second, as a management decision support system to be used in the kinds of functions noted above. More specific evaluation of potential model contributions is presented further below.

The following command level problem areas were identified by FTC, Norfolk personnel in December 1974 as areas in need of additional support (not necessarily areas seen as amenable to model development). These were evaluated in the user T&E using a specific set of criteria related to potential model contribution (see Appendix E). Summary results are indicated.

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\*Much of the information for this section was gathered from the application of a consistent set of criteria to a number of test problem areas. The criteria were applied by each of the User T&E team members and the Acting Director of Training (DOT) at FTC, Norfolk. (See Appendix "E").

1. Instructor Personnel Recap Reports (e. g., instructor allowance list, assigned vs. allowance, instructor requirements and assignments by course, etc.).

This information problem area was seen as occurring on a monthly basis and to be of substantial magnitude. Present methods were seen as being adequate most of the time for addressing this area. It was indicated that the problem area is likely to persist into the future. Views on the opportunity for improvement were mixed, ranging from small to substantial. Possible dollar savings on this area were seen as generally minimal. Non-monetary benefits were seen as moderate. The need for changes to current organization in order to implement improvements was seen as minimal. The model data base seen as quite applicable to this area.

2. Determining Impact of Changes in Student Throughput Upon Instructor Requirements (within available activity resources).

These kinds of problems seem to occur semi-annually or at most, monthly. Their magnitude ranges widely. They are likely to be extant well into the future. The opportunity for improving problem solving capabilities here is seen as substantial with prospective savings estimated in the 10K to 100K range annually per activity. Present methods were seen generally as being inadequate most of the time for these types of problems. The SCRR and TPF models were seen as applicable here.

3. Determining Effect of Changes in Contact Hours on Instructor Requirements and on the FTC in General.

This problem type occurs yearly or semi-annually and is of substantial magnitude. Present methods are usually inadequate but opportunity for improvement is seen as quite variable, depending on the command in question. (Dollar savings projected at 10-100K per command per year.) Moderate organizational changes were seen as being required to implement improvements.

The data base and SCRR model were seen as applicable to these problems.

4. Predicting Attrition Based on Student Profile and Course Length Data.

There was highly mixed assessment of this problem area. Data obtained at FTC, Norfolk failed to produce statistical correlations for formal school training of sufficient significance. It was thought that research into this area should continue. Presently, the DOTS models do not adequately address this area, though they might be made to do so.

5. Assessing Present or Potential Effects of Instructor Cross Training on Organizational Efficiency.

Problem could occur semi-annually and is of substantial magnitude. Present methods are usually inadequate and opportunity for substantial improvement is present (\$ savings in 100K range yearly per activity). Small to moderate changes in current organization and policy are seen as necessary to implement improvement. Data base and SCRR model are seen as addressing this area.

6. Effects of Training Staff Personnel cuts upon Organization Capabilities.

This problem occurs monthly to semi-annually and is of critical magnitude. Present methods are generally seen as adequate most of the time with mixed views existing as to opportunity for improvement. Possible dollar savings range from zero to millions. This problem area's likely to persist into the future. Moderate to substantial organizational changes are seen as necessary to implement improvements. Data base, SCRR and TPF models are viewed as applicable.

7. Effects of Changes in Convening Frequency Upon Organizational Efficiency.

Present methods seen as inadequate with substantial opportunity for improvements (possible savings in 100K to million dollar range). Minimal changes in present organizational policies are required to implement improvements. Frequency of problem occurrence seen as

ranging widely (daily to yearly). SCRR and TPF models are seen as applicable but statistical backup (e. g., use of student profile data) noted in item 4 above is needed to take full advantage of potential for improvement.

8. \*Effects of Changes in Facilities upon Capacity and Staff Requirements.

This problem type was seen as seldom occurring at FTC, Norfolk. Other reactions (apparently based on other training sites) indicated monthly to yearly occurrence of major magnitude. Present methods are viewed as generally inadequate with opportunity for improvement depending on command (10K to million range). Moderate changes in present policies are required to take advantage of opportunity. SCRR model is seen as applicable here.

9. \*Assessing Resource Interrelationships (e. g., effect of changes in one resource upon another).

This problem is of major magnitude with current methods usually inadequate at TRACOM level but usually adequate at CNTT. This type of problem will persist into the future, presenting great opportunity for improvements (100K to million dollar range). Moderate organizational changes will be required to implement improvements. Problem is of daily nature.

SCRR and TPF models are seen as applicable. However, these models are not currently configured to conveniently answer certain types of these questions such as interactive effects of convening frequency vs. class size, or the assessment of interactive effects over a range of variable values. Programming additions would be required to more effectively meet this information need.

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\*These last three problem areas were not among those initially identified by FTC, Norfolk managers. They were added to more completely assess potential model contribution.

10. \*ILS Design

This problem area currently exists to a major degree in CNTT and will do so in the future at the TRACOMS. Present methods are seen as inadequate most of the time with substantial to great opportunity for improvement (million dollar area). Moderate to substantial changes in present organization/policies are seen as necessary to effect improvements.

11. Other Factors Affecting Contribution

A major consideration in the realization of model potential was determined to be the level and manner of model use. While operation of the model mechanisms per se (e. g., terminal operation) is not complex, use of model results requires all of the skills of the experienced training manager. Typical model support requirements (e. g., documentation, ease of use) were viewed as essential to potential realization. (See "Ease of Use" and "Organizational Implementation" sections that follow.)

Several participants viewed the bulk of model potential to lie in application at the "functional" level and above (i. e., "models and necessary support may not be worth it at schoolhouse level"). On the other hand, participants with "schoolhouse" level experience expressed the view that considerable opportunity exists to utilize model potential, given "a little managerial imagination". A concise assessment of actual contribution can only be obtained via a field test (which FTC, Norfolk was not).

A possible hindrance to vertical expansion of model application is the plethora of overlapping management systems which reside at the upper management levels. While the integration of these systems is not within the scope of DOTS, higher level implementation of DOTS development may be jeopardized nevertheless. Coping with this dilemma remains a future challenge to the DOTS project management.

A recurrent theme of the T&E discussions centered on the NITRAS data system (i. e., its shortcomings). The complementary characteristics of the DOTS data base management system was recognized. Specifically, DOTS presents a way for effectively utilizing the vast NITRAS data base in a proactive way.

## Ease and Practicality of Use (Second Discussion Area)

### User Knowledge Requirement

Training in use of the DOTS model will be needed at all training command levels, though to varying degrees. Essentially three levels of training are required. These are familiarization for upper management, system analysis for translating upper management or command training problems into model parameters, and a systems operation for training those who would operate hardware components of DOTS. The familiarization course would emphasize applications of DOTS in problem solving, decision making, and report generation. The system analysis course would provide an in-depth applications course emphasizing the flexibility of DOTS in problem-solving, program modification, and data base maintenance. The systems operation course would be a fall-out from the system analysis course (without the systems analyst function). The system operation course would be centered around hardware operation -- learning to operate input and output devices and update the data base.

The requirement that the systems analyst should be able to translate problem areas and give preliminary interpretation to DOTS output, dictates that extensive knowledge of training command policies/functions will be needed by the analyst. DOTS model usage skills should be, of course, secondary to training command expertise. Programming experience is needed in order to modify models or for inputting special data onto temporary (scratch) files. Systems operator would not have to have special skills, although familiarity with computing system operations would probably be useful.

In most cases (except at central configuration management level), system analysis and system operation would be collateral duty for the personnel involved. Identification of personnel for analyst/operator functions, and training of these personnel, would be a command

responsibility. The systems operator course would probably be about 2 weeks long, while the system analysis course would last 2-4 weeks (especially if programming and data modification skills are to be taught). The familiarization course would last 1-2 days. A recommendation was made to incorporate familiarization/system analyst courses into training manager schools (as part of "how-to" models training).

Training for the system operator would be made easier if editing and interactive programming were standardized among the three models. Also, a more extensive procedures manual ("cookbook") is needed, for system operators/analyst. The manual should describe more applications (problem) areas, and procedures required to operate the DOTS system in association with these specific problem areas. A more accessible data elements dictionary is required for more efficient data/program updates, verification and modification by the systems analyst. In addition, a basic guide which details assumptions and fixed parameters of each model should be provided, especially for more accurate interpretation of model output by upper management and systems analysts. These manuals and guides would also be useful in training.

Standardization of editing and interactive programming among the three models is especially necessary to recover efficiently from default situations. As currently configured, it is too difficult to recover if errors occur or modifications are required because edit/re-edit procedures must be repeated, and these procedures are highly specialized for each model. Some capability to restart without resetting previous conditions should also be developed. This development should consider trade-offs between restart capability and interactive programming costs.

Additional tasking should address development of a reports manual for each model. Such a model would define the model parameters used in generating reports. This would add accuracy to interpretations, and encourage more upper management use of DOTS.

The current configuration at FTC, Norfolk has the TPC acting as system analyst who serves as "link" or "buffer" between command executives and instructors and system operators. Access to DOTS is therefore available at all levels through these analysts. This procedure appears to make for better translation of problem statements and may save processing costs, but little documentation or experience exists to substantiate these effects or that more direct access from upper and lower levels would result in more use/abuse.

Training for DOTS should occur as soon as possible after reporting aboard (at least at local command level), not only so that models will be effective over a longer period, but also to provide trainees with a better understanding of the total training command system early, and therefore reduce experience required to effectively manage within the TRACOM. (This is spin-off from models).

#### Update Requirements

It was difficult to evaluate this area because sufficient new problems were not used in the T&E. Program (model) updating/modification would probably be rare for routine (local command) report-generation. A more extensive program update requirement would probably exist at upper management levels for resolving projected ("what-if") problems. Updating of master data base and configuration control of programs (models) should be centrally managed, and should be specified prior to completion of R&D phase. Central management currently resides with system sponsor (CNET N-5), and should remain at this level for short-term (2-3 year R&D phase). Long-term (operational) management will reside with system manager who will provide operations/program support. The system manager may eventually be an activity like NETISA, but as stated above, this should be determined near end of R&D phase and by the system sponsor.

The capability exists for data base/model changes at the local command ("school house") level via scratch discs, although these modifications will probably not be

frequent. These modifications can be made on the scratch discs without endangering master systems. This scratch capability permits resolution of problems which are specific to local commands. These modifications could involve additional parameters such as assigning course priorities, accounting for deployment status of local ships, flow patterns between facilities, or optimization of other resource variables (such as "scientists/technicians" and "projects" instead of "instructors" and "students" for the CNETS). These modifications and extraneous applications should be covered and documented in future tasking. In addition, the feasibility of these modifications/applications should be addressed.

Update/modification requirements in the case of upper management may center around problems involved in integrating DOTS with other information systems. A serious effort should be undertaken to determine complementary functions among these information systems if redundancies are to be minimized and efficient integration and upper management usage are to be attained. This effort is not part of the current DOTS mission or tasking.

Although configuration management will be centralized, major training centers should have terminals which will provide the scratch capabilities previously mentioned. TRAPAC representatives states that terminals may be clustered around major training centers for providing common and specific data, and for resolving local problems. Common data from all centers would then be provided to the system (configuration) manager (preferably on-line via batched magnetic tape or disc input instead of mailing flat-paper or punched cards). Common data base updating should be routine and periodic (about once a week) for most data elements. This will permit effective use of DOTS by insuring that perishable data is fairly recent and that the data are uniform (for time) across commands. Local commands and centers would have access to lateral (other local) data bases (or to command specific data in master data base) on an "as required" basis.

A future tasking requirement exists to develop a planning document showing geographical/functional distribution of finalized DOTS hardware system, as well as software capabilities and software central sources. A functional flow chart should also be developed for the TRACOM showing scope and frequency of decision making information/problem solving required at all levels, including specific examples of problems and methods/flow used to resolve these problems. A finalized DOTS may include expanded data base (more parameters) and modified models if this functional flow analysis shows such a requirement exists. This information may include additional courses common to many schools and centers, as well as additional input from other information systems such as NITRAS.

Basic data collection/verification/input to the master data base would be responsibilities of local commands (centers). These procedures are more acceptable than with other current information because local commands would have direct access to central system. These commands would also have to manage problem-solving requirements unique to the command or center. This responsibility, however, is viewed as a benefit to local users inasmuch as it permits resolution of local problems without upper management intervention. Such a benefit should improve the reliability/validity of master data base input because the local commands would require reliable/valid data to resolve local problems. The final data management system may be similar to that presently used for CMI.

The T&E Team did not think the programs and data base associated with the SCRR&TPF models would be frequently updated in the operational phase. Although the data base of the ETE\* model might require frequent update, this should not present much of a management problem because the master data base would not be involved (only scratch disc). The ETE model per se would probably

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\*It was strongly indicated that the name of the ETE model should be changed to the more appropriate title, "Training System Simulator."

not be frequently updated. Updating of any model would probably be done within two weeks for most single-factor modifications. This timeframe depends on the interaction of these factors with others in the model, however.

The SCRR & TPF models appear to be useful at all TRACOM levels, while ETE is more useful at the local ("school house") level. Approval of permanent ETE model changes would have to be coordinated at system manager level. The T&E Team believed that neither master data base nor program modifications would be difficult if proper justification for making these modifications could be demonstrated (through findings of R&D or training effectiveness evaluations).

Inasmuch as DOTS is primarily a projection/management system which provides information for "what if" questions, its use as an information/report-generating system would be redundant, and would represent gross underusage of the system. Information/report generation would not be adequate justification for use at local or upper management levels. DOTS is not primarily an information collecting/collating system, but instead provides optimization of information output from other systems (i. e., NITRAS). The three DOTS models evaluated should be viewed as subsystems within a TRACOM MIS.

#### Response Times

If used as an information gathering system only, DOTS would not substantially improve on response times associated with other available systems. Response times for actual manipulations are associated directly with frequency of the problem-solving requirement.

#### Output Form

The needs to be standardized, but the reformatting requirement should be easily accomplished as the system is refined.

### Miscellaneous

It was determined that the restrictions (sole source) placed on DOTS by the proprietary RAMIS DBMS were not acceptable, and that although an interactive programming capability was necessary for DOTS, the RAMIS system should either be purchased by Navy or a similar system should be obtained permanently from another source. Additional tasking should identify these other sources. These sources should have the following characteristics:

1. A data base management capability.
2. An interactive programming capability.
3. Report-generating capability.
4. Capability to program in higher language as per current DOD/DON requirements.

## Data Requirements (Third Discussion Area)

### Nature of the Data Utilized by the Models

The data appears valid. There may be a requirement to add some method for validating relationships of data, etc., beyond standard format checks.

A capability is needed to easily add/modify data elements. This may be satisfied through the continued use of a data base management system (DBMS). A DBMS should be a mandatory feature of the system, if ease of use is to be retained.

The TPE model's treatment of backlog does not properly represent the phenomenon nor is it related in any predictable way to "Demand". What are the factors involved and the difficulties in getting these data? There may be a requirement for data from BUPERS, etc.

Some sort of training reservation system would be needed to gather better demand and backlog data. The T&E should be expanded to examine viable alternatives (one exists at COMTRAPAC).

"Bureau Capacity" and "Demand" variables used in the models are of questionable utility for some locations. Retain this as "Capacity A" and "Capacity B" for local use vice a specific use throughout the system.

The "J" number is no longer used.

To encourage maximum validity, data elements standardization should be accomplished in accordance with current instructions.

Some additional data elements may become necessary. Caution should be exercised in view of the costs associated with gathering, validating, etc. The variables and constraints in the model can represent other elements

or resources other than those described in the documentation. The various levels of application, i. e., CNET, CNTT, SSC, FTC, COMTRALANT/PAC may drive the need for additional elements.

Ensuring accurate data will ultimately require a system to provide for local validation of data as part of the submittal system. This would be part of the feedback process. If the originator has data available, and uses it, the validity of the data should be greater.

Conclusion: The core of the data base is NITRAS data which, as "raw data," is relatively valid, reliable and accurate, (except as noted above).

#### Data Availability

The data are presently available, largely without additional cost. Perhaps all the data is not available at CNTT activities. Perhaps less detailed data would be required if models were utilized at higher management levels. Summaries should be available (or at least the capability) at higher echelons. A belief exists that data entry should remain at the activity level. This would assure accuracy of submission and avoid possible over generalization of problems at higher echelons.

#### Data Accessibility

The data is not presently either easily or regularly accessible. (I. e., Programs must be written to extract the available basic data.) Some sort of on-line system for gathering and reorganizing data would be ideal. Accessibility by users should be controlled in order that the system user has access to only his own data. Other data would be available on an as required basis. Right to privacy considerations will of course apply if future use is made of the presently dormant student profile data.

#### Data Management

Data base is manipulatable in a very impressive way, however, the system for accomplishing this manipulation

is not Navy owned and is equipment specific. The data is effectively centrally managed, through the NITRAS reporting system. The T&E team concluded that even with all the existing problems in NITRAS, further improvement and corrective actions to improve the existing system should be fully supported throughout the EDTRACOM.

#### Future Data Problems

Essentially covered under previous discussions.

#### Other Discussions

The usability of data to be accessed by the DOTS family of models relates directly to the NITRAS/NAVTIS problems; such problems as validity, accessibility, availability, etc., hinge on NITRAS and other systems (example, SHORSTAMPS SHOROC, etc.) either operational or under development of being implemented. The DOT models must be viewed as a capability/application consistent with the total Training Command MIS and not as a separate system. From specific and general comments by attendees to this T&E, a strong display of feeling was evident that the EDTRA Command is in dire need of management in the area of systems development and coordination. Specifically there is the current problem of a lack of coordination of systems development and interfacing. There is a requirement for an overall information systems management/development function that is independent from the operational administration of the ADP facilities in the EDTRACOM. Some form of information systems study/development function has to exist that addresses the needs of all levels of the Command, not just CNET. This could be implemented through the use of a central coordinating function at CNET not associated with the present ADP administration function, and staffed with representatives (NON-ADP) from various functions and levels throughout the EDTRACOM. Serious doubt has been expressed about most systems under development in that there are varying overlaps of objectives, redundancy in data, and duplication in reports generated when all systems are viewed jointly. Additionally, the strong possibility exists that by and large the systems now under development or proposed are

essentially designed to serve only the CNET level of need and are of little or no utility to the operational levels and functional levels of the EDTRACOM except in several unique cases. Very little effort appears to be directed towards the development systems like DOTS which have the inherent capacity to become viable planning tools (i. e., for forecasting, modeling, etc.) or as tools for evaluating various approaches to resource utilization.

## Organizational Implementation (Fourth Discussion Area)

### Levels of Application

Discussion: Specific level(s) and degree of application of the DOTS models cannot be defined at this time. The considerations which preclude such definition are essentially the lack of costing information and lack of experience based on application beyond FTC, Norfolk. Discussions regarding systems costs and economy of operation centered, in the main, on whether or not schoolhouse - level implementation could ever be shown to be economically feasible or even justifiable. This argument centered on the premise that the unavailability of precise costing data notwithstanding, the thrust of implementation should be toward the functional level, in that only at this level would the magnitude and complexity of problems warrant the capability to apply modeling techniques.

Counter - arguments stated the premise that costs would in all likelihood be minimal to the point that they would not be the primary deterrent to systems implementation; and further, that there were many ways in which the models could (should) be used at the activity level. That the amount of usage and attendant benefits to be derived from such use is limited only by the imagination and resourcefulness of the activity itself.

Conclusion: Throughout the T&E we have been hampered by a lack of costing data. We are unable to predict with any degree of validity what this capability might cost in any of its terms (hardware, software, personnel, telecommunications, site prep) much less as a whole. This is not a criticism, in that derivation of systems costs was not a goal of the effort to this point, but rather a statement of fact. This fact does serve to highlight the other issue however in that while activity level usage might be great in terms of numbers of interactions, does the utility warrant the investment? We cannot say at this time. The most we can say is that if continued evaluation is directed, that a portion of that evaluation must address the economics of the system and that the economic evaluation

must address alternative methods of application as well as levels.

Relationships of Models to Existing Policies and Structures:

Discussion: The potential for contribution by the DOTS models in the overall planning area is its most significant feature. The need for accurate, timely planning is well recognized and there are several systems now operational or under operational development and implementation which purport to provide this capability (none appear totally satisfactory be it a function of scope of concept or of performance). DOTS is envisioned as a possible device to effect the changes required in these various systems to provide a truly reliable and accurate MIS with the added ability to model. This added capability should provide, through linear programming and optimization techniques, training managers a most valuable and highly responsive tool to aid in the decision making process. (Costs notwithstanding). Considerations concerning receptivity, resistance and incentives centered about the concerns of unnecessary higher echelon involvement with everyday problems most appropriately addressed by the cognizant activity, and the ability of the system to provide real time information and assistance to the user . . . as contrasted to present systems wherein the activity realizes no return on their input investment. Even with the concern expressed above, it was the consensus that given further evaluation the activities would be receptive to using the models. Implementation support was considered generally excellent.

Conclusion: If the DOTS concept did nothing more than precipitate an investigation and realignment of the current morass of Training Command MIS(s) it would be of value. Given that it will provide capabilities to model and simulate and therefore project as well, it is potentially of great value.

The central point is that DOTS is not to be another system separate and distinct from those already in

being. It must not be competitive. It must be complementary to a total MIS established from the myriad of (unintegrated) systems that now exists. Similarly, DOTS (as a function of the total Training Command MIS) must interface with those systems external to the Training Command, such as SHORSTAMPS, that will impact on the Command.

While the ETE and highly conceptual ETAM models would appear to have the least impact external to the Command, they might have the greatest impact within. The magnitude of the individualization effort within CNTT alone, and the projected savings from this effort, would support continued R and D of these models.

## User Investment (Fifth Discussion Area)

### Personnel Resources

Would specially skilled people have to be acquired or could present staff learn to operate models on the results? The group's consensus was that no additional personnel would be needed. That while some training could be necessary, present staff can learn to use the models/results. In most cases the wider familiarity with the program within the command the better. Resources would have to be identified to accomplish configuration management (hardware and software) and necessary coordination/instruction among commands using DOTS and between DOTS and other systems. Most likely this would be accomplished best by some present facility with the necessary expertise and experience in this area.

How much additional staff time would be required to operate, maintain and utilize the models and their data base? This variable is largely unknown at this point. It is however directly related to use which is a function of the acceptance and utility of the models themselves.

### Hardware

What hardware acquisitions would typically have to be made? Many existing hardware configurations now in place at potential user sites could be used for DOTS. The minimum requirements (i. e., keyboards/printers) would suffice in many cases. CRTS and other more sophisticated peripherals would not be necessary in many locations. In a good many cases, communicating magnetic card typewriters could fulfill all the hardware requirements for access to the DOTS system, without significant impact on present use of this equipment. Many training activities already possess such equipment. In a non-time share application of these systems, more significant hardware acquisitions would be necessary unless surplus capacity on Government controlled equipment was available. In either case program update capability via magnetic

tape and sufficient disc storage capacity are required as is some Data Base Management/Rapid Access Report Generation System. For these reasons and others addressed above, DOTS will be most efficiently utilized as a commercial time share system.

What is the Approximate Cost? Present cost data are based on general estimates provided by IBM. Certain general conclusions are possible. However, detailed cost analysis is required prior to submissions of an ADS plan. This should be undertaken with qualified personnel at a time subsequent to the T&E. Cost will be dependent on a variety of factors including but not limited to:

- Hardware configuration
- Processing time
- Necessity for changes
- Number of ultimate users
- Future expansion
- Mode of operation
- Relation with other systems
- Extent of data collection/reduction etc.

Per unit cost will be amortized better with greater incidence of use, and total cost can be reduced if hardware requirements are kept to a minimum.

Given findings in first and fourth discussion areas, what might be a "ball park" cost per incidence of usage ratio. \$20K a year estimate by IBM seems excessive if hardware is largely in place.

#### Method of Operation

##### Time Sharing

For the short term (2-3 years)

Commercial time - sharing appears to be the only feasible alternative while the project remains in ADO form.

### Other Discussion

A general agreement evolved during discussion of user requirements to the effect that expansion of the prototypical modeling system to TRAPAC and CNTT activities is justified. Such expansion would address a wider variety and greater frequency of training decision making conditions, explore the interfaces necessary to complement existing and developing systems, expand the data base, increase familiarity with modeling as a technique, potentially improve collection of related data, and provide better indications of system potential than would an extensive effort to go operational at this time. Each problem area presented to the models for information generation in support of decisions inherent in the problem should be carefully documented during this phase for later evaluation with regard to system costs. Certain commands expressed concern about spending that much money over a period of time without guarantees that continued access to the system would be provided. Future phases of DOTS should test a variety of operational set-ups under minimum hardware/support conditions, under a cluster or network configuration, etc.

### Conclusion

This whole area is essentially a moot point unless and until an ADS plan is necessary. This requirements seems to be about 1-2 years away. If this system progresses to a recommendation for operational implementation, system specifics should be left to further determination during the procurement process and be done in such a way as to ensure investigation of all possible configurations with attendant costs. (See Appendix H for pertinent instructions.)

## User T&E Conclusions and Recommendations

The following conclusions and recommendations were made by the User T&E members:

- . DOTS should be continued as an ADO.
- . The thrust of DOTS should be modified to include the investigation of applications at higher levels (i. e., beyond FTC) within CNET.
- . The ETAM project, while not addressed specifically in the T&E, warrants support in view of information provided to date.
- . The next phase of DOTS should include field test(s) of the developed models, under operational conditions.
- . Investigation of the potential management improvements embodied by DOTS underscores the need to integrate and synthesize the plethora of management support systems internal to or impacting upon CNET upper level management (e. g., STREPS, NITRAS, MAPMIS, RACS, CENTRA, CMI, NATIS, SQC/TEAS-TRS, NCFA, SHORSTAMPS).
- . Upon the formulation of a draft T&E report, a future meeting of CNET function representatives should be held in order to finalize the T&E. An end product of this meeting should be a specific statement of commitment from the various CNET functions regarding the future of the DOTS project. This should include organizational support and participation in the project.

## MANAGEMENT SUMMARY

### Introduction

This test and evaluation dealt with three computer based models that were selected, developed, and validated for application at the Fleet Training Center, Norfolk, Va. The total cost of this segment of the DOTS program is estimated at about \$780 K. The following outcomes have resulted from this expenditure:

- (1) A determination of the feasibility of applying management science techniques to improve Navy training management.
- (2) Three working models were developed and documented that have potential as tools to address a broad array of training management problems and have specific applicability to fleet training.
- (3) A data base framework was developed which is approximately 90% consistent with data presently being reported within CNET (i. e., NITRAS) and within which data have been collected and refined for FTC, Norfolk. This provides a potential means for facilitating present and future reporting of command training information to NITRAS or other CNET management information systems.
- (4) Application of a standard data base management system (RAMIS) to the above data base.
- (5) Establishment of a working management information center at FTC, Norfolk which utilized the models, data base, telecommunications equipment, and trained operators.
- (6) Extensive documentation of the models, their rationale, and operation.
- (7) Exposure of a considerable number of key Navy training managers to the possibilities for applying management science techniques in the solution of their problems.

The 780K referred to above represents approximately half of the total expenditures for the DOTS project to date. To avoid misinterpretation of the T&E it is important to emphasize the distinction between an evaluation of a segment of the project, as summarized below, and an evaluation of the project as a whole. The following provides an indication of DOTS developments which were not dealt with directly by this T&E:

- Comprehensive functional study of NAVEDTRACOM
- Strategic assumptions for the 1980 decade
- Delineation of technological gaps in the training system
- Initial test of the feasibility of using simulation
- Development of the Educational Technology Assessment Model (ETAM)
- Naval Training Program Requirements Study and Model (Dahlgren)
- Study on application of decision theory to CNET
- Audio-Visual aids for orienting Navy training managers to the nature and use of management science techniques

### Feasibility Assessment

It is the conclusion of this analyst that the DOTS models have established beyond reasonable doubt the feasibility of applying modeling techniques to Navy training management problems. This general finding is a composite of the elements of technical, operational, and economic feasibility as discussed below. The three models can be dichotomized. Most importantly there are the System Capabilities/Resources Requirements Model (SCRR) and the Training Process Flow Model (TPF), which are resource allocation/process flow type models. Secondly there is the Educational Technology Evaluation Model (ETM) which is a simulation based course design tool for Independent Learning Systems (ILS).

### Technical Feasibility

The SCRR and TPF models are very complementary in nature and share a common level of application. It is not surprising at all that these two model types were selected for development. It is fair to say that it was not necessary to perform the extensive analysis of Phase I to make the determination that a resource allocation model and a process flow model should be among the forms first attempted for CNET. Phase I, indeed was a necessary step in identifying where each model would be best applied and for identifying the greater system environment in which they must operate.

Certainly, the models are not uniform in their current level of technical development. For example, the Training Process Flow Model (TPF) failed to reach some of its envisioned goals in that statistical analysis of student profile data failed to produce correlations of significance enough to warrant inclusion in the model. As a result, the TPF presently does not have the capability to relate the school-house process to the characteristics of incoming students. However, while failing to establish the feasibility of the statistical approach, it hardly proved its infeasibility. In fact, the nature of the analysis conducted begs alternative approaches which might be taken in the future. In its current nonstatistical form, the TPF has shown that it can be a useful tool in the hands of training managers by taking full advantage of presently available data and certain operationally utilized, if still ill-defined, planning factors extant in the current training environment. Additionally, the TPF seems to have carried the brunt of initial data base development for the two models.

The SCRR model demonstrates the technical feasibility of providing training center managers with more accurate and multi-dimensional assessments of their training capabilities. Like the TPF, it takes advantage of existing planning factors such as the student/instructor ratios which reflect basic requirements formulas in order to determine organizational requirements on the basis of the interaction of resources and capabilities. When more precise planning factors become available in the future (e. g., through the SHORSTAMPS program), they can be easily assimilated into the model.

The constant returns to scale assumption of the linear program does not appear to be a limiting factor in its application within the training environment. Though the "step" function is perhaps most descriptive of the relationship between training resources and output, there is no basic inconsistency with the LP approach, especially in view of integer and mixed integer formulation options.

The SCRR, in a sense, is an automation of what is currently being done mentally by instructors and training managers. This is viewed as a plus. Using the SCRR, within the course of an hour, it might be possible to develop as many resource allocation alternatives as a training manager could develop in two weeks. This advantage, of course, would be multiplied many times over considering frequency of occurrence. Add to this the capability for optimizing across resource allocation alternatives and one can see that the SCRR presents the potential for some very real and immediate payoffs for the training manager.

The SCRR and TPF models were developed in a fleet training environment. Here the demand is characteristically unprogrammed. It is reasonable to believe that in other Navy training sectors where demand is much more programmable (e.g., technical training), the potential for effective model development is at least as great if not greater than has been demonstrated for the fleet environment.

In contrast to the SCRR and TPF, the ETE model focuses on the course - its design and, to some extent, its management. It is quite independent from the other models in both content and context. It is not nearly as organizationally limited as the other two and theoretically has applicability wherever ILS courses are designed, modified, or where a significant number of such courses must be managed given some commonality of resource requirements.

No particular faults could be found with the composition of the ETE. Its primary problem is that while none of the models were strictly field tested, the ETE was the least tested of the lot. In the absence of ILS at FTC, Norfolk, the model was validated against an actual ILS course at Corry Station. The results of this validation, while thoroughly documented, do not provide insights to how useful the model can be to actual users. Besides being a very limited test (i.e., one school), the validation was against the results of another simulation model (in this case, a special purpose type). This resulted in substantial proof that the ETE, despite its generality, could perform in superior fashion to a system specific model in a given case. It does not tell anything about whether there will be much opportunity for use of such a model given the nature of the EDTRACOM's operations. A more meaningful test of the appropriateness of the ETE to current or future Navy training problems was apparently limited by the unavailability of appropriate subject courses.

### Operational Feasibility

Data. The SCRR and TPF models were developed to be consistent with data currently being collected. Inputs to the NITRAS data base (which are supplied to CNET) were used to comprise a common data base for the two models. Certain additional data elements were collected directly from the FTC; however, these comprise only a small portion of the total data base. All of the data used by these models are both available and accessible within CNET. About 90% of the data must be collected for reporting to the NITRAS, regardless of model requirements. The situation is not just peculiar to FTC, Norfolk, but is true throughout the CNET commands.

The data base is currently managed using the RAMIS software. This is a proprietary data base management system developed by Mathematica and widely available from time-sharing vendors. However, the interactive (i. e., conversational) version of RAMIS is only available from the time-sharing vendor (NCSS) currently being used to support the models. With RAMIS as a management device, the model data base is very satisfactory in its content, flexibility and accessibility. Supposedly, the NITRAS will have a similar data base management capability in the future. However, at present, that system has extensive problems. As presently setup, the data base could run parrallel to NITRAS until such a time as that system is fully capable of supporting the models. In fact, from information revealed at the User T&E in June, it appears that DOTS' use of NITRAS data provides a good model for what can be done with the data elements currently being reported by commands.

It is important to keep in mind that the models currently require a data base management capability such as RAMIS in order to operate. Even a change to a comparable DBMS will require some software modifications. On the otherhand, with the availability of data base management systems such as RAMIS, it would have been wasteful to have used project funds to develop a similar capability .. especially since this was a feasibility study.

The ETE data are supplied directly by the user via a conversational prompting program. The data required for the ETE are fairly simple in comparison to those needed by the other two models and their supply seems to present no operational problem.

Organizational Implementation. Extensive consideration was given to this aspect of operational feasibility throughout the T&E. The on-site User's T&E was especially arranged to have prospective CNET users react and provide feedback as to the feasibility of the models given their respective organizational frameworks. The results of those proceedings are presented in the detailed T&E report. In general, members of the User T&E team viewed the models as operationally feasible at the TRACOM and schoolhouse level. Additional feedback later obtained from COMTRALANT and COMTRAPAC reinforced this finding. However, feedback obtained from CNTT claimed that the operational feasibility and desirability of the models had not been demonstrated at Norfolk. The essential pitfall of the models as viewed by CNTT is that they "have been primarily designed to help that level of management least requiring assistance in

decision-making." (i.e., the school house). CNTT construed this view as being supported by the acting Director of Training at FTC, Norfolk, who reported to the T&E team that the need to answer "what if" questions was rare (i.e., 5 or 6 times a year) at the FTC level. (Of course the Director also had many good things to say about the models. He recommended their continued development at the TRACOM level and hoped that the FTC could have continued access to the models on a periodic basis.)

Comments on User T&E Results: While CNTT's point is sound in its premise (i.e., that the FTC site is atypical of the greater EDTRACOM), it has deviated somewhat in its conclusion (i.e., that the operational feasibility of modeling has not been demonstrated). Phases II and III of DOTS have shown that meaningful and useful models can be constructed for the benefit of training management. It has also revealed that the most effective residence for such models in fleet training may be at the TRACOM level.

In no way can this line of reasoning be extended to say that the models thus far developed are appropriate to CNTT's most critical management problems. As CNTT has implied, the selection of the FTC as the development site largely precluded this possibility from the beginning of Phase II.

In fairness to CNTT, it should be said that their alarm that someone might try to spread these particular models across the waters of EDTRACOM is not without cause. Much of the DOTS documentation concerning "Projected operations" of the models invites this kind of fear (e.g., TAEG Report No. 12-2, Vol I, Phase II Overview, pp IV-15 through IV-19). Such presentations seem to imply that the three models, with a minimum of modification, could be applied in a very systematic manner through much of CNET. This sort of thinking was further embellished by verbal presentations from IBM which emphasized that there would have to be fairly significant changes in the present Navy training organization in order to take full advantage of the models.

The models themselves neither require nor warrant such incipient aggrandizement. They are good examples of how basic management science technologies can be utilized to assist in the solution of specific management problems. As such, they imply that establishment of a program, chartered to utilize management science techniques in the support of Navy training management would be

well founded. Such a program should not operate on the basic assumption that there is a total integrated solution to the training management problem, but rather on the objective of achieving incremental improvements in management effectiveness by providing useful solutions to important management problems - regardless of their limited generality.

Opportunities for applying the models at the TRACOM level look exceedingly good. Both COMTRALANT and COMTRAPAC seem receptive to application of the models in their respective organizations. Both commands have the necessary equipment for supporting interactive management models (TRALANT could use equipment currently being leased at FTC in connection with DOTS). At TRAPAC a civilian position which would have responsibility for data base and model developments is being created. No such position has been thus far identified at TRALANT. It may be possible to utilize one of the training managers from FTC, Norfolk, who already has familiarization with DOTS in the model interface role. It is essential that an individual within each of the two commands has clear responsibilities associated with the implementation of the models.

Ease and Practicality of Use. This aspect of the models was judged as satisfactory in the User T&E. Update requirements for the data base were not excessive. The basic structure of the models could remain stable. Actual operation of the models was possible with a minimum of training. The interactive nature of the model and data base programming contributed highly to the ease of use. Approximately two weeks would be a reasonable time for training an operator using basic skill types presently available on the organization's staff. Considerably more time would be required to fully educate training managers in potential uses of the model - if for no other reason than that it would be best to extend such training over time thereby allowing real and current problems to serve as examples in the training.

Documentation. The present documentation is satisfactory and should serve well in future utilization of the models. Though a users' guide has been documented, there still remains a need for an operator's manual which fully explains model options, error messages and corrective measures. It is understood that such a manual is presently being prepared by IBM.

### 3. Economic Feasibility

A benefit/cost analysis was attempted in TAEG Report No. 12-2. A short coming is its assumption that the models as presently configured could be widely applied throughout CNET. As pointed out above, this premise must be rejected. There are other reasons why the benefit/cost analysis provided by the contractor is not acceptable. These will be identified in the detailed T&E report.

It appears that a reasonable benefit/cost analysis of the models can only be derived from a valid field test. It must be established to what extent the models supplant existing procedures or personnel and what additional capabilities are provided - even more importantly what these capabilities buy in the way of greater effectiveness.

Numerous attempts were made during the T&E to trace back from the application of the models to real problems emanating from the FTC and in turn to assess the benefits of supporting the solution of those problems. None of these attempts resulted in very useful information. (At present, representatives of TRAPAC and TRALANT are conducting exercises with the models using real world problems. It is hoped that these exercises will result in more definitive assessments of potential model payoffs.)

Certain rather unavoidable problems contribute towards this situation. First it is difficult to get managers to perceive, let alone use, sophisticated models when their prime concern at the moment lies in the basic data area. Second, certain uses of the models harbor implicit threats to members of the organization's staff. For example, if the SCRR model was used to show that substantial cuts could be made in the present staff without effecting performance, it might jeopardize getting further information or support of the project from that staff.

With the dearth of information on the benefit side of the feasibility question, it is best to focus on cost factors. Here it can be seen that the future cost of developing and operating the models may prove to be effectively less than even assessed by the contractor in his analysis. This position can be supported because of two concurrent developments to DOTS. First, the data base necessary for future model development is, in the main, being compiled regardless of DOTS. Thus, the cost of that data acquisition and maintenance

need not be attributed to the DOTS models. Secondly, the TRACOMS either have or are in the process of procuring the necessary hardware to support DOTS type models, again, regardless of DOTS. For example, TRAPAC already has in operation a terminal with full telecommunications capability from which the models have already been accessed. Thus it is doubtful that users would need to purchase equipment that they would not have procured otherwise.

The time-sharing cost per usage of each model is well within reason (User Test Guide Appendix V, 30 May 75). Time-sharing, of course, obviates the need for large initial investments in ADP hardware, thereby putting the models on a largely "pay as go" basis. It does not appear that additional staff would be necessary to support the models in TRACOM operation. Modifications should not prove extensive for TRACOM application. All in all, these factors point to a very low cost for implementation and operation in the projected TRACOM application. As a result, it would not require very much "benefit" to break even in such a project.

As for proving the financial feasibility of applying modeling techniques in general throughout the EDTRACOM, it is not believed that this could presently be established. Applications can differ so markedly with respect to cost and payoffs that any specific application hardly provides a basis for extrapolation of feasibility for the general case. The history of management science is strewn with examples of very good general models which never were implemented. Situational factors for each case seem to override any generalizations that might be made.

## Recommendations

### Recommendations for the Conclusion of DOTS (FY-76)

1. Initiation of data collection and review for TRALANT/TRAPAC application and field test of SCRR-TPF. This should include a clear assessment of opportunities for model contributions at these commands. Each command should designate an individual from its staff who will be the primary interface point in model development and have a clear responsibility for seeing that the models get put to real and practical use within the command to the extent possible.
2. Modification of the SCRR model as necessary in order to apply it at the TRACOM level.
3. Review/modification of the TPF model in terms of the following considerations:

- The capabilities of a DBMS (e. g. , RAMIS) to supplant the TPF in its current functions (given that no satisfactory statistical parameters can be developed).

- Possibilities for more efficient model design given that the week by week simulation is equivalent, in effect, to successive transformations of course parameters using vectors of proportionality factors on a quarterly basis.

- The possibility for alternative approaches to the development of statistically based model parameters.

- Modifications as necessary to accommodate TRACOM level application.

4. Design and fulfillment of field tests of the SCRR/TPF at TRALANT and TRAPAC.

5. Presentation of the ETE model to the core of ILS course developers in the EDTRACOM. This to be followed by field testing of the model in several cases of actual course design. An assessment of the benefits of the model should be made following these tests and the model should be further developed, revised, or put on the shelf for operational use as appropriate.

#### Recommendations for a Future Program Resulting From DOT5

1. Review training management problems within the CNTT command. A logical first step would be to determine if and how the Phase I analysis was incorrect or incomplete with regard to its description of the CNTT functions. However, this review should not be approached from the standpoint of how the presently developed Phase II models can be made to fit CNTT problems. (If this is a possibility, it should make itself obvious in any event during the course of the analysis.) Rather, the approach should be to determine how a training management support program (see below) could best serve CNTT's needs.

2. At the conclusion of the TRACOM application/field test, a program should be established devoted to the use and development of management science techniques to support training management throughout CNET. The agent for this program should reside within the CNET community but have close ties with the R&D sector. This group would serve as a two-way funnel for both translating CNET R&D requirements

and for implementing advancements emanating from R&D. More importantly the group would have the capability to directly address management support requirements as possible within the state-of-the-art. This group could provide an invaluable element of continuity and consistency in the solution of such problems within CNET. The DOTS Phase I products, as corrected or amended, should provide an excellent foundation for this program. The models developed thus far would be the start of a "tool kit" of models or other techniques that could be applied to problems as they arise within the training community.

3. The results of the DOTS project, primarily the application of data base management technology, should be integrated more closely with the work of the NETISA organization in the development of the NITRAS data base.

As a final remark, it should be noted that while the objective of the DOTS ADO is viewed as being achieved, the magnitude of expenditures that were required should be a lesson in the pitfalls of setting up projects which are a priori tasked with pleasing everybody. It is a conviction here that, at least for the present, the successful application of management science technology is much more likely through many small scale applications.

APPENDIX A

T&E EXCERPT FROM TDP 43-03 P01A

## 5.2 Test and Evaluation Plan

A. Design. The design focus will be on the Naval Education and Training Command (CNET) system although interfaces with the total Navy Education and Training System will be considered. Experimental models of the CNET system will be conceptualized, formulated, described, developed and computer-programmed. The models will possess the capability of accepting different parametric values (a) of variables impinging upon the CNET system (e.g., mental group variations in input populations to schools); (b) of variables within the CNET system (e.g., available school seats for a particular week, month, etc.); and (c) of variables reflecting state-of-the-art condition (e.g., reduction in training time through the use of programmed instruction). Output will be provided in the form of cost and effectiveness measures.

B. Test. The studies will be designed to test how the models may be used for effective planning and decision-making within the CNET system. This design will test the predictability and generalizability of the mathematical models to the entire Naval Education and Training System.

The Fleet Training Center (FLETRACEN), Norfolk, Virginia, a sub-element of CNET, and Commander, Training Command, U. S. Atlantic Fleet (COMTRALANT), has been tentatively selected as the test bed for test and evaluation. The FLETRACEN was selected because it: (1) has an extensive mix of schools; (2) is subjected to unpredicted requirements for new courses, quotas, etc., and (3) includes all functions in the training development cycle between course design and course implementation.

The test design will include experimental variables required for test and evaluation of the model through digital simulation and will utilize historical data where available for assessing the required generalization and predictability of the modeling. In this manner, the Naval Education and Training Command will be provided with a viable facility for effective management control over the Navy Education and Training System, and a consequent gain in effectiveness, quality, and quantity improvements in the system. The on-site test will be conducted in the form of a field verification by an independent testing activity.

A program for continued technical improvements in the models and growth to simulation will be provided, as well as recommendations for incorporation of educational technology features into the selected models.

5.2 Test and Evaluation Plan (Continued)

C. Evaluation. The final determination of feasibility will be in terms of technical, operational, and financial considerations.

(1) Technical feasibility evaluation will consider the state-of-the-art in mathematical programming models applied to designing training systems. Consideration will be given to areas of already demonstrated applicability, areas requiring additional development, and areas clearly needing a technological breakthrough.

(2) Operational feasibility will be assessed through an analysis of the ease and convenience with which the models may be utilized by various decision-making echelons within the CNET organization. Additionally, the models will be evaluated as to their ability to interface with other personnel planning and forecasting models either already in existence or under development.

(3) Financial feasibility will be determined through comparison between the personnel, hardware, and support costs required to operate the model and the real and estimated reductions in cost anticipated through use of the models.

APPENDIX B

IDENTIFICATION OF DOTS T&E PARTICIPANTS



DEPARTMENT OF THE NAVY  
TRAINING ANALYSIS AND EVALUATION GROUP  
ORLANDO, FLORIDA 32813

TAEG:WHL  
8 April 1975

From: Director, Training Analysis and Evaluation Group, Orlando,  
Florida 32813  
To: Commanding Officer, Naval Personnel Research and Development  
Center (Attn: F. DiGialleonardo) Bldg 200, Washington, D. C.  
Subj: TDP 43-03, Subproject PO1A, Design of Training Systems (DOTS),  
test and evaluation (T&E); information concerning  
Ref: (a) TAEG ltr TAEG:WHL of 17 Jan 1975  
Encl: (1) Preliminary User's Test Guide  
(2) Test and Evaluation Perspective and Goals

1. As stated in reference (a), a preliminary User's Test Guide (enclosure (1)) is forwarded for possible use in the development of a test and evaluation plan.
2. The on-site test and evaluation of the DOTS models at the Fleet Training Center, Norfolk, Virginia, has been scheduled for 23-27 June with a formal training course for T&E members 16-20 June.
3. Representatives from the Chief of Naval Education and Training and its Functional Commands who will assist NPRDC in the performance of the formal on-site T&E have been identified. The personnel selected are as follows:

CNET

Mr. E. Scheye  
Systems Management, N-336  
AV 922-3695

COMPTRAPAC

LCDR T. L. Ferrier  
Training Analysis and ADP Officer  
N-31  
AV 957-4219

COMTRALANT

Dr. Havey Thorstad  
Education Specialist, FTC  
AV 690-4183

TAEG:WHL  
8 April 1975

Subj: TDP 43-03, Subproject PO1A, Design of Training Systems (DOTS),  
test and evaluation (T&E); information concerning

CNETS

LCDR R. J. Biersner  
Human Factors Analysis, N-214  
AV 922-1392

CNTECHTRA

CDR J. D. Davis  
Assistant for Management, 015  
AV 966-5375

Dr. Norman Kerr  
Training Research, 0161  
AV 966-5593

4. Enclosure (2) provides a general statement of the overall goals of the T&E within the perspective of the research and development effort.

5. As agreed in previous discussions between TAEG and the NPRDC Washington Branch, the T&E plan should be completed by the first of May and distributed to the T&E representatives.

*A. F. Smode*  
A. F. SMODE

Copy to: (w/enclosure (2))  
NPRDC (J. Silverman)  
CNET (Mr. E. Scheye, N-336)  
CNETS (LCDR R. J. Biersner, N-214)  
COMTRAPAC (LCDR T. Ferrier, N-31)  
COMTRALANT (Dr. Harvey Thorstad)  
CNTECHTRA (CDR J. C. Davis, Code 015)  
(Dr. Norman Kerr, Code 0161)

## APPENDIX C

### DOTS TEST AND EVALUATION PLAN



DEPARTMENT OF THE NAVY

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER  
WASHINGTON BRANCH OFFICE  
BLDG 200 WASHINGTON NAVY YARD  
WASHINGTON, D. C. 20374

25 April 1975

From: DOTS Test and Evaluation Coordinator,  
NPRDC Washington Branch Office

To: Distribution List

Subj: DOTS Test and Evaluation Plan; distribution of

Ref: (a) TAEG ltr TAEG: whl of 8 April 1975  
(b) TDP 43-03, Subproject P01A, Design of Training Systems  
(DOTS), April 1974.

Encl: (1) Test and Evaluation Plan for DOTS Phase II Models

1. Reference (a) identified representatives from the Chief of Naval Education and Training and its Functional Commands who will assist NPRDC in the test and evaluation of models produced within the scope of reference (b). These representatives will comprise a User Evaluation Team that will be coordinated by the undersigned during an on-site T&E to be conducted at the Fleet Training Center, Norfolk, Va., 23-27 June.

2. Enclosure (1) provides an overview of the T&E in general, and the specific role of the User Evaluation Team.

3. Comments regarding the content of enclosure (1) are solicited.

*Frank D. Digialleonardo*  
FRANK DIGIALLEONARDO

Distribution:

CNET (Mr. E. Scheye, N-336)  
CNETS (LCDR R. J. Biersner, N-214)  
COMTRAPAC (LCDR T. Ferrier, N-31)  
COMTRALANT (Dr. Harvey Thorstad)  
CNTECHTRA (CDR J. C. Davis, Code 015)  
(Dr. Norman Kerr, Code 0161)

Copy to:

NPRDC (Mr. J. Silverman)  
TAEG (Mr. H. Okraski)  
(Mr. W. Lindahl)

C-1

## Test and Evaluation Plan for DOTS Phase II Models

### Introduction

Under the provisions of Technical Development Plan (TDP) 43-03.01A, April 1974 titled Design of Training Systems (DOTS), the Navy Personnel Research and Development Center (NPRDC) has responsibility for conducting a test and evaluation of training management models developed in Phase II of DOTS. This plan provides an overview of the manner in which the test and evaluation will be conducted.

### Scope

The test and evaluation (T&E) will consider technical, operational and financial aspects of three models developed under DOTS: (1) the System Capabilities/Requirements and Resources Model (SCRR); (2) the Educational Technology Evaluation Model (ETE); and (3) the Training Process Flow Model (TPF). In addition, capabilities provided for integrating these models (where applicable) and their supporting data base will be similarly evaluated.

The T&E will extend to other DOTS developments in addition to the above, only to the extent that they impact upon the basic utility and validity of the above models. The T&E does not have as part of its objective a study of the form or level of detail required for DOD approval of Automated Data System (ADS) development. However, the desirability and feasibility of proceeding to such a study will be addressed.

It is obvious from the number and magnitude of possible T&E considerations delineated below (see Approach) that a full assessment of each is beyond the time and resources available to the T&E study. All of the considerations will be addressed to some extent; those most in need of in depth analysis will be pursued. Other areas will be left for further study as may be desirable based upon the conclusions and recommendations of the T&E.

### Resources

The T&E will be conducted using NPRDC staff. External consultations will be made with respect to specific technical aspects of the models as required. Representatives of prospective users of the models within CNET will assist in the T&E. These include COMTRAPAC, COMTRALANT, CNTT, FTC Norfolk, CNETS and CNET. Representatives of the Training Analysis and Evaluation Group (TAEG), and the DOTS monitors, and of the IBM corporation, the model developers, will be requested to provide assistance as required. Specific areas of T&E responsibility are indicated below.

Information sources, in addition to the above, will include DOTS technical reports, IBM conducted validation, test procedures and results,

activities responsible for data used by the models, data on operating cost of the models, and other prospective users that may be identified during the course of the T&E. DOD requirements concerning the development of automated data systems (e.g., DOD Manual 4120.17-M) will also be referenced.

### Approach

Technical Considerations. Technical considerations as used herein refer to (1) the relationship between the kinds of information produced by the model and the information needed by management in the real world, (2) the manner in which the information is developed within the models, and (3) the data upon which model values are based. Relevant subjects include the following:

a. model selection

- fit of model to problem
- complementary aspects of the models to each other
- time frame for model operationalization
- potential payoff of problem area addressed
- data support requirements
- level of decision making addressed
- acquisition, analysis, and use of problem/process descriptive data to develop model selection and design criteria

b. model application

- selection of parameters
- simplifying assumptions
- design logic
- data accessibility
- data validity/accuracy
- manager-model interaction

c. model analysis and validation

- accuracy
- predictive capability
- sensitivity
- method of validation
- representativeness of test site and data used in model development

Operational Considerations. Operational considerations as used herein refer to factors effecting implementation, use, and maintenance of the models in real organizations. Relevant subjects include the following:

- a. ease and practicality of use
  - user knowledge requirements
  - update requirements
  - response time
  - time required to use order of results (i. e. , model output)
- b. institutionality of data sources
  - data availability
  - data accessibility
  - data management
- c. organizational implementation
  - prospective levels of application
  - relationship of models to existing policies and structures (i. e. , change requirements)
  - plan for implementation
  - training program(s) for facilitating implementation and reducing resistance to change
- d. magnitude of required user investment
  - personnel resources
  - hardware
  - maintenance
  - other fixed and variable resource requirements
- e. method of operation
  - stand alone (batch)
  - interactive
- f. supporting documentation
  - user manuals
  - program documentation

Financial Considerations. Financial considerations as used herein refer to the cost of implementing, supporting and maintaining the developed models. The objective here will be to determine if, and to what extent, it is financially feasible to implement the models through the training system. Development cost of the models to date, while a consideration of the T&E, is a sunk cost with respect to further implementation. Relevant subjects include the following:

a. costs of implementation

- cost of developing special supporting data system, if any
- operating cost of the models
  - projected level of operation (see below)
  - projected extent of use at any level
  - ADP support alternatives (e.g., time sharing, dedicated system, decentralized system)
- cost of additional model development or integration
- cost of training in model use and maintenance

b. range of potential impact and levels of implementation

- minimum level of implementation
  - costs
  - benefits
- maximum level of implementation
  - cost
  - benefits
- implementation alternatives

c. shelf life of models

- model structure
- model factors (e.g., ratios, rates)

d. compatibility of models to existing ADP systems

e. computational basis for assessing benefit

Discussion

Most of the considerations delineated above have been addressed in one form or another in existing and soon to be published materials produced by TAEG/IBM. This information will be closely reviewed

and discussed with the model developers. Independent verification or collection of additional information will be made as required. Many of these points will be explored during the DOTS model training course (16-20 June) and subsequent on-site user test and evaluation (23-27 June).

The user test and evaluation will take advantage of the presence of representatives from prospective CNET users to focus primarily upon the operational considerations of the models as outlined above. A model evaluation framework, in written form, will be provided to members of the user test and evaluation team (9 June). Users will be requested to utilize this framework to evaluate the models during and following the training course. The user evaluations will be discussed on an individual basis for the purpose of obtaining clarification and elaboration. Group discussions will be held among the user team to address specific issues. IBM or TAEG personnel will be called upon as required to provide further explanation concerning particular aspects of the models to the team members. The user team will collaborate to draw up a summary assessment (draft) at the conclusion of these discussions. Additional information may be required; user team members will be encouraged to discuss the models and the model evaluation framework with other CNET functionaries upon return to their respective organizations. NPRDC will coordinate the composition of a final statement of user evaluation after such additional information is collected from the members.

### Responsibilities

As stated above, the user evaluation team (i.e., CNET representatives) will be responsible for the development of a comprehensive statement of evaluation focussing on operational aspects of the models. NPRDC will coordinate this user evaluation and take primary responsibility for technical and financial assessment. (User evaluation team contributions to these latter two areas will be welcomed and, indeed, may be specifically requested by NPRDC.) TAEG will be responsible for the provision of required information and coordination with IBM and CNET functionaries. NPRDC will be responsible for developing a final report detailing the results and findings of the T&E effort.

### Schedule

The following is a list of dates relevant to the T&E.

- 1 May - NPRDC distribution of T&E plan to TAEG and CNET participants
- 31 May - Final DOTS test plan from IBM/TAEG
- 9 June - NPRDC distribution of User evaluation framework to CNET participants
- 16-20 June - DOTS Training Course, FTC NORFOLK
- 23-27 June - User test and evaluation; draft evaluation statements
- 14 July - Final inputs from CNET test and evaluation participants to NPRDC coordinator
- 31 August - Completion of T&E and report of findings
- 31 September - DOTS final document package

## APPENDIX D

SCHEDULE AND OUTLINE FOR USER

T&E OF DOTS MODELS



DEPARTMENT OF THE NAVY

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER  
WASHINGTON BRANCH OFFICE  
BLDG 200 WASHINGTON NAVY YARD  
WASHINGTON, D. C. 20374

NPRDC:FD:gbg  
3 June 1975

From: DOTS Test and Evaluation Coordinator, NPRDC  
Washington Branch Office  
To: Distribution List

Subj: DOTS Test and Evaluation, 23-27 June 1975, FTC  
Norfolk, Va.

Ref: (a) NPRDC;WBO ltr to distribution list, 25 April 1975,  
Subj: Distribution of T&E Plan

Encl: (1) Schedule and Outline for User T&E of DOTS Models  
(2) DOTS Expanded Milestone Chart and Assignments for  
IBM, T&ET and FLETRACEN, 23 April 1975

1. Reference (a) forwarded an overview of the T&E as it will be approached by NPRDC. As stated in that plan, it is essential that the subject T&E result in a clear assessment of the operational feasibility of the DOTS models. Towards that end, enclosure (1) is forwarded for information, review and comment. The schedule may be adjusted on the basis of comments received from the team members (preferably via phone before 16 June).
2. It is understood that an assessment of operational feasibility cannot be made totally independent of technical and financial feasibility considerations. It is expected that information concerning the latter areas will develop during the course of subject User T&E at Norfolk. However, the main responsibility for these two areas will be borne by NPRDC extrinsic to the subject User T&E. Informal support from the User T&E team members is likely to be sought during this endeavor. But, due to the time constraint on full-time team member participation, it is prudent that the subject User T&E focus as sharply as possible upon operational feasibility considerations.
3. It is expected that each team member will be able to make substantial progress towards an evaluation of the models as a by-product of the training session in DOTS model usage (16-20 June).

4. Enclosure (1) is a fairly detailed schedule and outline for the T&E week. The assessment of the models and data base will be approached through five major discussion areas. There will be a discussion leader and recorder for each area. All five areas will be covered within the first three days of the week, leaving the last day and a half for the composition of a draft T&E.

The responsibilities of each discussion leader will be as follows:

- a. Develop essential points for discussion (enclosure (1) contains a good start towards these).
- b. Pace the discussion and observe time constraints.
- c. Follow-up questions which remain unanswered after the discussion session (time is provided in the schedule for this activity).
- d. Review written summary of the discussion in his area, as well as notes made by the team members during the course of the discussion.
- e. At a later time (see schedule) take the lead in developing a draft section for his discussion area.

The responsibilities of the recorder will be as follows:

- a. Make a written record of the essential remarks made during the discussion, as well as the summarization and any subsequent modifications. (This written record need not be in smooth or narrative form, nor is it essential to stipulate who said what. The important thing will be to get the remarks in writing so that they can be later reviewed by the team and ultimately developed into a draft T&E statement by the discussion leader.)
- b. See that the notes get to the typist as soon as possible and that they are distributed to the team members by the afternoon of the following day.

A verbal summarization of each discussion will be made by the T&E coordinator at its conclusion. Following this, omissions, corrections and modifications as noted by the team will be invited and recorded.

Each team member will be responsible for making notes on discussion points that he sees as particularly important. These notes should

be conveyed to the recorder or discussion leader as appropriate. Each member will also be responsible for making comments as necessary on the recorded summaries of each session and providing these to the appropriate discussion leader for inclusion in the draft.

All team members will participate in the formulation of a draft T&E assessment during the last two days of the week. The T&E coordinator will be responsible for transforming the draft into a smooth version subsequent to the T&E week.

It is expected that the various DOTS models will be available for further "hands on" experience during the T&E week. Team members are encouraged to bring to the T&E, representative test problems that might be tried-out.

5. Enclosure (2) contains additional and summary information on the DOTS program. The "Test and Evaluation Goals" stated therein do not constrain or modify the T&E plan as outlined in reference (a) or partially detailed in enclosure (1).

6. I am looking forward to working with each of you. A valid assessment of the models developed under DOTS is a formidable, though necessary task. I am pleased that the T&E will be able to benefit from your expertise in the area of training management and from your insight to the requirements of the CNET community.

Sincerely,



FRANK DIGIALLEONARDO  
Area Code (202) 433-4760  
Autovon 288-4760

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(Dr. R. Sorenson)  
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(Mr. E. Hooprich)  
TAEG (Mr. H. Okraski)  
(Mr. W. Lindahl)

SCHEDULE AND OUTLINE FOR USER T&E OF DOTS MODELS  
16-20 JUNE 1975  
FTC, NORFOLK, VIRGINIA

23 June 1975 - Monday

8:00 Introductory Remarks

8:15 Individual team members' discussion of particular interests and objectives in the T&E.

9:00 Presentation and Discussion of Week's Schedule; adjustments as necessary.

9:30 Assignment of Duties

Discussion Leader  
Recorder  
Summarization/Feedback  
Additions, exceptions, modifications

10:00 Break

10:15 First Discussion Area: Potential Model Contributions

Discussion Leader: DiGialleonardo  
Recorder: Thorstad [changed to Brooks]  
Summarization: DiGialleonardo

A. At the Activity Level

- general nature of contributions
- specific areas of contribution (e. g., which training functions, organization)
- source of contribution (i. e., which model)
- ranking of contributions by area/ model e. g.,

- 0 none
- 1 low
- 2 moderate
- 3 substantial
- 4 very high

- importance of application area to CNET/CNO  
(e.g., same ranking as above)

B. At other levels (e.g., sub-activity level, larger commands, CNET level).

- (similar considerations as for A above).

C. Other discussion as necessary.

3:30 D. Summarization

4:00 E. Omissions, Corrections, Modifications

Adjourn: 4:30

24 June 1975 - Tuesday

6:00 Second Discussion Area: Ease and Practicality of Use

Discussion Leader: Biersner  
Recorder: Thomas  
Summarization: DiGialleonardo

A. User Knowledge Requirements

- Knowledge about the problem

What level of decision making expertise is needed to formulate the problem?

To obtain model results?

To utilize the results of the model run?

- How much time is necessary and what difficulties are involved in obtaining about knowledge requirements?

B. Update Requirements

- What update requirements exist for the models and their data base? (e.g., student/instructor ratios, student profile/course performance relationship, etc.)

How extensive are these update requirements?

Can they be easily supported within current training activity operations?

- What level of expertise is needed to make the updates?
- How frequently would they probably need to occur?

C. Response Time

- How much time is required to prepare a typical model run?
- How much time is required to make a typical model run?
- How much time is required to analyze and apply the results?

D. Output Form

- Is the form and level of detail of the model output amenable to direct usage or must the user make significant transformations?
- How extensive are the required transformations?
- In the typical problem how much of the solution comes from the model and how much from other sources (e.g., discretion of the decision maker)?

E. Other discussion as necessary.

F. Summarization

G. Omissions, Corrections, Modifications

(11:30 - 12:30 Lunch)

12:30 Distribution of previous day's summary for review.

12:45 Third Discussion Area: Data Requirements

Discussion Leader: Scheye

Recorder: Ferrier

Summarization: DiCialleonardo

A. Nature of the Data Utilized by Models

- Are the data valid? (i.e., do they measure or otherwise represent the right phenomena given their use in the model?)
- Are the data reliable (i.e., are they consistently reported from one time period to another? Is the method of data reporting standardized?)
- Are the data accurate? (i.e., given what they are to represent, is the representation usually correct?)

B. Data Availability

- Are the data required presently in existence?
- If not, what would it take (in time and money) to institute the data source and reporting mechanism?

C. Data Accessibility

- Can the data be easily obtained on a regular basis?
- What data interface problems exist? (e.g., format, language).
- What "domain" problems exist? (e.g., right to privacy, organizational sanctions).

D. Data Management

- How easily is the data base manipulated and maintained?
- To what degree is the data centrally managed.

E. Future Data Problems

- Which of the above data considerations would become critical as the models are spread throughout CNET and as attempts to aggregate data and model results are made?

F. Other discussion as necessary.

G. Summarization.

H. Omissions, Corrections, Modifications.

25 June 1975 - Wednesday

8:00 Fourth Discussion Area: Organizational  
Implementation

Discussion Leader: Davis  
Recorder: Scheye  
Summarization: DiGialleonardo

A. Prospective Levels of Application

- Within activities.
- Beyond activities.
- Do the models support current decisions or decisions which should be made but currently are not?
- In the latter case, what roadblocks exist to creating such decision-making processes?

B. Relationship of Models to Existing Policies and Structures

- Do the models support or seek to change current policies and structures?

Are various CNET activities likely to be receptive in either case?

What are the incentive's for prospective model users to become actual model users?

Have possible bases of resistance been considered in the model development program?

Has a specific plan for implementation been formulated or has an implementation strategy been worked out?

How well do the models fit in with future plans for the CNET organization?

C. Implementation Support

- What is the quality and coverage of the training programs that have been developed?
- What is the quality and coverage of the user's manuals and other documentation that has been developed?
- What CNET organization(s) would sponsor and/or support the implementation of the models?

D. Other discussion as necessary.

E. Summarization.

F. Omissions, Corrections, Modifications.

(11:30 - 12:30 Lunch)

12:30 Distribution of Previous day's summaries for review.

12:45 Fifth Discussion Area: User Investment

Discussion Leader: Ferrier

Recorder: Biersner

Summarization: DiGialleonardo

A. Personnel Resources

- Would specially skilled people have to be acquired or could present staff learn to operate models or use results?
- How much additional staff time would be required to operate, maintain and utilize the models and their data base?

B. Hardware

- What hardware acquisitions would typically have to be made?

- What is their approximate cost?
- What would be approximate time sharing or other ADP charges for main frame usage?
- Given findings in First and Fourth discussion areas, what might be a "ballpark" cost per incidence of usage ratio?

C. Method of Operation

- Stand alone?
- Time sharing?
- Other?

D. Other discussion as necessary.

E. Summarization.

F. Omissions, Corrections, Modifications.

26 June 1975 - Thursday

8:00

Each discussion leader will prepare a draft of the T&E Team's findings with respect to his discussion area. Dr. Thorstad will assist CDR Davis with the draft on the fourth area (Organizational Implementation). Mr. Thomas will assist Mr. Scheye with the draft on the third area (data requirements). Unanswered questions arising out of the previous days discussion sessions or the composition of the drafts will be followed-up through calls to the appropriate TAEG or IBM representatives (coordinated through Mr. Lindahl) or to other sources as required.

Final summarizations from Wednesday should be distributed by noon. Comments on each summary should be communicated to the appropriate discussion leader for consideration in the draft.

Typing of drafts should begin as soon as possible.

27 June 1975 - Friday

9:30 Begin review of draft segments.

12:00 Completion of draft review; adjournment

Completed working draft (smooth, final version will be developed by the T&E coordinator at a later date. Members will be encouraged to take copies of the draft back to their respective commands for review and comments that might be later included in the final version.)

APPENDIX E

TEST PROBLEMS AND CRITERIA FOR EVALUATION  
OF POTENTIAL MODEL CONTRIBUTIONS

The following pages contain a listing of possible problem areas towards which the models developed in the DOTS project might be effectively directed. Most of these problem areas were identified through discussions with training managers at FTC, Norfolk. Also included are two lists of questions relating to these problem areas.

In providing the information requested, it is suggested that you first scan the outline of possible problem areas, circling each one that has relevance to your particular CNET organization/function. Any additional problem areas that seem to be relevant but not included in the outline should also be noted for subsequent evaluation. Next, proceed to the criteria of Part One and respond to each with respect to each problem area that you have identified as relevant. (A separate criteria list should be filled out for each relevant problem area.) Finally, answer the questions in Part Two. (These need be answered only once.)

Please provide your name, position and name of your organization/function below.

## TEST PROBLEM AREAS

### I. Instructor Personnel Recap Report

A. Purpose - To provide the training program coordinators with a six month picture of a school's instructor status in order for him to detail incoming instructors where most needed.

#### B. Needed

1. Instructor allowance list
2. Instructors assigned versus allowance - personnel filling the allowed billets combined with a listing of assignments not covered by a billet.
3. Totals recapitulation: Allowed On Board  
Rate for rate  
NEC for NEC  
Total for total.
4. Specific course information:
  - a. Instructors required
  - b. Instructors qualified
  - c. Instructors rotation dates.

### II. Effect on number of instructors required if:

- A. Student throughput is increased
- B. Student throughput is decreased
- C. Student decrease required to permit 'X' reduction in number of instructors.

### III. Contact Hours

- A. Total contact hours at FLETRACEN
- B. How many instructors are required for an average of:
  - 30 contact hours
  - 25 contact hours
  - 20 contact hours
  - 15 contact hours
  - 10 contact hours
- C. Same questions as 'B' broken out by each school.

### IV. Lowering attrition rate:

- A. If a student is a volunteer for the course, all other factors being equal, how much more likely is he to pass than a non-volunteer?
- B. What effect does student/instructor ratio have on attrition rate?
  1. If GCT/ARI lowered but desire to maintain a low attrition rate what student/instructor ratio would accomplish this?
  2. What student/instructor ratio is required to reduce attrition rate?

(Continued)

- C. What attrition effects can be expected from course lengthening or shortening:
1. All other things being equal.
  2. Decrease in instructors.
  3. Decrease in GCT/ARI entrance requirements.

### Cross-Training

- A. Given the courses which are amenable to cross-training plus the qualifications required to teach that course, determine:
1. Which schools contain the instructors meeting eligibility requirements.
  2. Average contact hours of that school.
  3. Number of instructors available for cross-training.  
Note: A factor will be the qualification time in the new course and whether or not an instructor can be released for that period of time.
  4. Once qualified what will be criteria for maintaining qualifications? Teach 'X' times per year?
- B. An accounting system will be required in order to readily identify to command cross-trained instructors.

### Personnel Cuts

Given a requirement for an 'X' percent personnel cut with:

- A. No corresponding reduction in students
- B. Corresponding reduction in students
- For each case determine:
1. Considering course priority system which courses should be cut?
  2. Based on course utilization which courses should be cut?

### Convening Frequency

If course convening frequency is reduced because it is experiencing a low utilization rate:

- A. Will the customers use the course less because the convening dates are not convenient?
- B. Are the requirements for graduates being fulfilled and are we doing this only because of the convenience of convening dates factor?
- C. Should class capacity be reduced?
1. If this is done will the number of instructors required be reduced?
  2. Is the no-show rate so high that reducing class capacity produces the same effect as reducing convening frequency?
  3. Is the attrition rate so high that this also creates the same effect?

### VIII. Facilities Utilization/Capacity

If Facilities are increased/decreased by "x",

- A. How many more/less courses can be offered?
- B. How many more/less instructors are needed at full utilization?
- C. How many more/less students can be trained?

### IX. Resource Interrelationships

- A. Given a certain change in student throughput requirements,
  - 1. What combinations of instructor resources, facility resources, and course convening schedule will permit the requirement to be met?
  - 2. What is the best combination the above factors in terms of
    - a. most efficient use of instructors?
    - b. most efficient use of facilities?
    - c. most convenient course convening schedule for customers?
- B. Given a change in courses demanded (required), what is the effect on
  - 1. instructors required (quantity and quality)?
  - 2. facilities required/utilized?
  - 3. student throughput capacity?
  - 4. number of convenings that can be scheduled?

## TEST PROBLEM CRITERIA

### PART ONE

For each test problem area that can be identified from the preceding outline (e. g., IV. B. 2.) or for any other pertinent problem area faced by your organization, please respond (✓) to the following criteria. (Multiple criteria lists are provided).

#### CRITERIA LIST

Problem area or decision: (Use code such as IV. B. 2 from outline or describe in narrative form.)

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---

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---

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1. How frequently is this problem encountered?

- a. yearly
- b. semi annually
- c. monthly
- d. weekly
- e. daily
- f. never (If never, ignore following questions and proceed to next problem area.)
- g. other state: \_\_\_\_\_

2. What is the magnitude of the problem as it currently exists?

\_\_\_\_\_

little or                  minor                  substantial                  major                  critical  
none

3. How adequate are present methods of dealing with this problem?

- a. adequate all of the time
- b. adequate most of the time
- c. inadequate most of the time
- d. never adequate

4. How likely is the problem to be significant in the near future (e. g., up to 1980)?

0                      .25                      .50                      .75                      1.0

Virtually              Not                      Likely                      Likely                      Virtually  
Impossible              Likely                      as Not                                           Certain

5. How sizeable is the opportunity for improving on present decisions or practices currently used in this problem area?

Minimal              Small                      Moderate                      Substantial                      Great

Why? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. What order of savings (annual) might be realized through effective solution of the problem on a regular basis? (For the subject organization only.)

- a. million(s) (\$)
- b. hundred(s) of thousands
- c. ten(s) of thousands
- d. hundred(s) of dollars
- e. less or none

Provide rough statement of rationale: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. What order of non monetary benefits could be derived from effective solution of the problem?

Minimal              Small                      Moderate                      Substantial                      Great

8. How much of a change in the organization's structure or decision making process would be required for effective solution of the problem?

Minimal              Small                      Moderate                      Substantial                      Great

## PART TWO

The models developed deal with certain major factors of the training environment. Based upon your experiences and information, assess the variability (✓) of these factors as it occurs in the real training environment within the normal planning horizon.

### 1. Student throughput (training demand)

- a. qualitative variability (i.e., changes in kinds or types of students)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

- b. quantitative variability (i.e., changes in numbers of students)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

### 2. Instructors

- a. qualitative variability (i.e., changes in kinds or types of instructors)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

- b. quantitative variability (i.e., changes in numbers of instructors)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

### 3. Facilities

- a. Qualitative variability (i.e., changes in kinds or types of facilities)

Relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

- b. quantitative variability (i.e., changes in numbers of facilities)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

#### 4. Courses

- a. qualitative variability (i.e., changes in kind of courses)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

- b. quantitative variability (i.e., changes in numbers of courses, convenings)

relatively fixed	moderately variable	widely variable
---------------------	------------------------	--------------------

APPENDIX F

POSITION PAPERS OF CNET AND FUNCTIONAL COMMANDS



DEPARTMENT OF THE NAVY  
CHIEF OF NAVAL EDUCATION AND TRAINING SUPPORT  
PENSACOLA, FLORIDA 32509

IN REPLY REFER TO

Code N-214  
3900

8 AUG 1975

From: Chief of Naval Education and Training Support  
To: Director, Naval Personnel Research and Development  
Center, Washington Branch Office, Bldg 200, Washington  
Navy Yard, Washington, D.C. 20374

Subj: Design of Training Systems (DOTS); comments on  
evaluation of

Ref: (a) FONECON between CNETS Code N-214 and Mr. Frank  
DiGialleonardo of NAVPERSRANDCEN, Washington Branch  
Office on 28 Jul 1975

Encl: (1) Draft copy of DOTS Test and Evaluation User Evalua-  
tion dated Jun 1975

1. Enclosure (1) has been reviewed for editorial correction as requested in reference (a). It is recommended that the final draft contain more data from user questionnaires which were administered during the DOTS evaluation held at COMTRALANT in July, especially documentation on bases for cost-savings estimates.

2. The CNETS would like to take this opportunity to recommend a more extensive field evaluation of the DOTS models, preferably at several training commands which have student and instructor resources which could best be served by the DOTS models. It is recommended that this evaluation be performed by a Navy activity, and that it carefully document upper echelon requests for training management information which could be provided by the DOTS models, times and costs involved in personnel training (systems analysts and operators), effectiveness of training, times and costs required to operate the hardware systems, and the frequency with which each model was used. Any cost-saving which results from use of the DOTS models should be documented, as well as critical decisions that were expedited through use of these models. It is further recommended that an effort be made to interface these models with available input/output hardware at these

Code N-214  
3900

evaluation sites, and that alternatives to the existing data base management system also be explored.

Charles B. Havens

CHARLES B. HAVENS  
By direction

Copy to w/o encl:  
CNET (N-56)  
TAEG



CHIEF OF NAVAL EDUCATION AND TRAINING  
NAVAL AIR STATION  
PENSACOLA, FLORIDA 32508

Code N-562  
5 August 1975

MEMORANDUM

From: Code N-562, Chief of Naval Education and Training  
To: Mr. Frank Digialleonardo, NPRDC Washington Branch Office,  
Bldg. 200, Washington Navy Yard, Washington, D.C. 20374

Subj: Review of DOTS Test and Evaluation, User Draft Report


Ref: (a) DOTS T&E meeting of 23-27 June 1975

Encl: (1) Annotated User Draft  
(2) Recommended references

1. In accordance with the general agreements(s) reached in reference (a) enclosure (1) is forwarded. No substantive changes were made. A final draft which incorporates the input provided by other T&E respondents is requested, prior to final approval. Enclosure (2) is provided as a ready reference for determining compliance with specific requirements as delineated by higher authority.

2. Continued communication on this project is desired. Please feel free to address any question germane to DOTS to the undersigned.

Sincerely,

  
EDWARD H. SCHEYE



COMMANDER TRAINING COMMAND  
UNITED STATES PACIFIC FLEET  
SAN DIEGO, CALIFORNIA 92147

FF8-1/31:rtb

1500

Ser 1997

16 SEP 1975

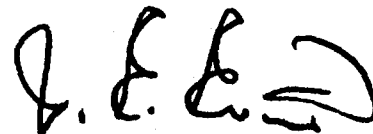
To: Navy Personnel Research and Development Center, Washington  
Branch Office (Attn: Mr. Frank DiGialleonardo)

Subj: Design of Training Systems (DOTS) (TDP 43-03, Sub-Project POLA)

Encl: (1) COMTRAPAC Position Concerning DOTS

1. The DOTS Project is presently undergoing test and evaluation, a feature of which is an assessment of potential user requirements for the product of the project.
2. Enclosure (1) is provided as a statement of position vis-a-vis DOTS.
3. Commander Training Command, U. S. Pacific Fleet has been experimenting with access to the DOTS models, and although certain equipment interface problems remain unresolved, access appears feasible without significant additional investment in either hardware or software.
4. Should further information of use in the T&E be developed, it will be forwarded to the Navy Personnel Research and Development Center, Washington Branch Office.

Copy to:  
TAEG, Orlando  
CNET

  
J. E. EVANS  
Chief of Staff

ORIGINATOR: LCDR T. L. FERRIER  
CODE: N31

COMTRAPAC SDIEGO

UNCLASSIFIED

A. SUBJECT/PROBLEM: DESIGN OF TRAINING SYSTEMS (DOTS) (TDP 43-03  
SUB PROJECT POLA)

B. FACTS/DISCUSSION: THE DOTS PROJECT RECOGNIZES THE NEED FOR INTRODUCING  
OPERATIONS RESEARCH AND MANAGEMENT SCIENCE TECHNIQUES INTO THE NAVEDTRACOM.  
THESE DECISION-AIDING MODELS ARE INTENDED TO:

1. INCREASE EFFICIENCY OF TRAINING RESOURCE UTILIZATION.
2. OPTIMIZE STUDENT FLOW
3. SUPPORT JUSTIFICATION FOR RESOURCE ALLOCATIONS.
4. INCREASE RESPONSIVENESS TO INFORMATION DEMANDS.
5. PROVIDE UNIQUE CAPABILITY TO TEST VARIOUS "MANAGEMENT STRATEGIES"  
PRIOR TO IMPLEMENTATION.

THE MAJOR PORTION OF THE WORK UNDER DOTS IS BEING PERFORMED UNDER  
CONTRACT BY THE INTERNATIONAL BUSINESS MACHINES (IBM) CORPORATION IN  
THREE PHASES. PHASE I WAS COMPLETED ON 1 DECEMBER 1973. THE FOUR BASIC  
OBJECTIVES ACHIEVED IN THIS PHASE ARE AS FOLLOWS:

1. A COMPREHENSIVE DESCRIPTION OF THE CURRENT NAVAL EDUCATION AND  
TRAINING SYSTEM, SHOWING THE LINES OF INTERACTION BETWEEN FUNCTIONS,  
DECISION POINTS AND THE MANAGEMENT CONTROLS ON THE SYSTEM.
2. STRATEGIC ASSUMPTIONS DESCRIBING, ON A PROBABILISTIC BASIS,  
THE SOCIAL, POLITICAL, ECONOMIC AND TECHNOLOGICAL ENVIRONMENTS FOR  
THE 1980 DECADE RELEVANT TO NAVY EDUCATION AND TRAINING.
3. RECOMMENDATIONS LEADING TO, AND A DESCRIPTION OF, AN IDEALIZED  
SYSTEM IN TERMS OF THE 1980 TIME FRAME.
4. A LIST OF POTENTIAL OR EXISTING COMPUTER-BASED MODELS THAT WILL  
IMPROVE THE DECISION-MAKING PROCESS.

PHASE II OF THE PROJECT, COMPLETED IN DECEMBER 1974, INVOLVED THE  
SELECTION OF THE MODELS TO BE DEVELOPED, DESIGN AND DEVELOPMENT OF THE  
MODELS, CODING AND INITIAL DEBUGGING, THE DEVELOPMENT OF DATA BASES FOR  
MODEL EXECUTION AND TESTING AND INITIAL VALIDATION. THE THREE MODELS  
SELECTED FROM A LIST OF 21 CANDIDATES FOR DEVELOPMENT IN THIS PHASE ARE  
THE SYSTEM CAPABILITIES/REQUIREMENTS AND RESOURCES MODEL, TRAINING

*Encl (1)*

UNCLASSIFIED

PROCESS FLOW MODEL AND AN EDUCATIONAL TECHNOLOGY EVALUATION MODEL. EVENTUALLY, THE MODELS SHOULD COMPLEMENT THE NAVY INTEGRATED TRAINING AND RESOURCES ADMINISTRATION SYSTEM (NITRAS) BY ADDING A PREDICTIVE CAPABILITY TO THE DATA BASE.

PHASE III OF THE DOTS PROJECT IS PRIMARILY A TEST AND EVALUATION EFFORT. THE MODELS DESIGNED AND DEVELOPED IN PHASE II HAVE BEEN EXERCISED, VALIDATED AND VERIFIED AT THE FLEET TRAINING CENTER, NORFOLK, VIRGINIA IN JUNE 1975, USING BOTH REAL-WORLD AND SIMULATED DATA IN A COMMAND AND CONTROL SETTING. A TIME-SHARED, COMMERCIAL COMPUTER TERMINAL WAS INSTALLED AT THE FLEET TRAINING CENTER IN FEBRUARY 1975.

A FORMAL TEST AND EVALUATION IS NOW BEING CONDUCTED BY A TEAM LED BY NPRDC (WASHINGTON BRANCH), TO DETERMINE THE POTENTIAL FOR UTILIZING THE MODELS AT SIMILAR TRAINING ACTIVITIES AND THE DESIRABILITY OF DEVELOPING RELATED "PARENT TYPE" MODELS FOR USE OF HIGHER ORGANIZATIONAL ECHELONS. OPERATIONAL, TECHNICAL AND FINANCIAL FEASIBILITIES WILL BE ASSESSED IN THE TEST AND EVALUATION. FINAL USER DOCUMENTATION WILL BE DELIVERED AT THE COMPLETION OF PHASE III.

AS PART OF THE T AND E, NPRDC HAS REQUESTED EACH USER TEAM MEMBER TO PROVIDE A WRITTEN STATEMENT OF COMMAND POSITION VIS-A-VIS THE DOTS PHASE III MODELS AND DATA BASE TO BE USED AS THE CAPSTONE OF THE OPERATIONAL FEASIBILITY PORTION OF THE T AND E.

C. RECOMMENDATIONS/CONCLUSIONS: RECOMMEND FOLLOWING AS COMTRAPAC POSITION:

1. THE MODELS SHOW PROMISE AND SHOULD BE FURTHER DEVELOPED.
2. SUCH FURTHER DEVELOPMENT SHOULD TAKE PLACE IN AN R & D CONTEXT CENTERING ON EXPANDING THE DOTS DATA AND AFFORDING FUNCTIONAL COMMANDERS ACCESS TO AND EXPERIENCE WITH DOTS MODELS AS A DECISION AID.
3. A MAJOR GOAL OF THE DEVELOPMENT OF DOTS SHOULD BE THE INTEGRATION OF NAVEDTRACOM AUTOMATED DATA SYSTEMS INTO COMPLIMENTARY MODULES OF AN EFFECTIVE AND MULTIFACTED WHOLE.
4. COMTRAPAC IS READY NOW TO ESTABLISH AN INTERFACE WITH THE MODELS AND TO CONTRIBUTE TO THE EXPANSION OF THE DATA BASE PERSONNEL RESOURCES PERMITTING.

## TRAINING PROCESS FLOW (TPF) MODEL

THE TPF MODEL PROVIDES, THROUGH SIMULATION AND A LARGE STATISTICAL DATA BASE, THE MEANS FOR ANALYZING THE RELATIONSHIP BETWEEN STUDENT ATTRIBUTES, TRAINING DEMANDS, AND COURSE CHARACTERISTIC IN ORDER TO ASCERTAIN THE OUTPUT RATE OF THE TRAINING SYSTEM UNDER CERTAIN PRESCRIBED CONDITIONS. THE IMPACT OF CHANGES TO ANY OF THE VARIABLES MENTIONED AT THE COURSE LEVEL CAN BE ASSESSED AT THE NEXT HIGHER ECHELONS, SUCH AS AT THE TRAINING CENTER LEVEL. THE MODEL PERMITS SYSTEM OPTIMIZATION ON THE PART OF THE DECISION MAKER BY PERMITTING HIM TO CONSIDER SUCH FACTORS AS THE MATCH OF THE TRAINING SYSTEM CAPABILITY WITH JOB REQUIREMENTS, STUDENT OUTPUT AS A FUNCTION OF STUDENT ATTRIBUTES, RESOURCE USAGE FOR GIVEN OUTPUT RATES AND MIXES. THE COSTS ASSOCIATED WITH ANY CONCEPTUALIZED (OR REAL) TRAINING SYSTEM CAN BE OBTAINED FROM THE MODEL.

SOME OF THE QUESTIONS THAT CAN BE ASKED OF THE MODEL ARE AS FOLLOWS:

- A. WHAT IS THE IMPACT ON RESOURCES OF INCREASING THE STUDENT INPUT TO A GIVEN COURSE?
- B. IF STUDENT INPUT REQUIREMENTS ARE LOWERED, WHAT WILL HAPPEN TO STUDENT ATTRITION?
- C. IF THE NO-SHOW RATE IS DECREASED BY A CERTAIN PERCENTAGE, WHAT WILL HAPPEN TO RESOURCE UTILIZATION?
- D. WHAT WILL BE THE EFFECT OF CHANGING THE WORKING SCHEDULE?
- E. HOW WILL MODIFICATIONS TO PERSONNEL DETAILING PROCEDURES AFFECT THE THROUGHPUT RATE AND PIPELINE TIME?
- F. HOW WILL THE THROUGHPUT RATE VARY WITH CHANGES IN INTERNAL TESTING CRITERIA?

THE ABOVE LIST OF QUESTIONS IS NOT MEANT TO BE EXHAUSTIVE BUT THE QUESTIONS ARE REPRESENTATIVE OF THE KIND OF DIALOGUE POSSIBLE BETWEEN THE MANAGER AND THE TPF MODEL.

## SYSTEM CAPABILITIES/REQUIREMENTS AND RESOURCE (SCRR) MODEL

THE PURPOSES OF THE SCRR MODEL ARE TO: (1) OPTIMIZE THE MIX OF TRAINING RESOURCES (CLASSROOMS, INSTRUCTORS, LABORATORIES) NECESSARY TO ACHIEVE A SPECIFIED OUTPUT PROFILE AND (2) DETERMINE THE MAXIMUM NUMBER OF COURSE CONVENINGS AND OPTIMAL MIX OF COURSES, GIVEN A SET OF RESOURCE AND TIME CONSTRAINTS. TO ACHIEVE THESE OBJECTIVES, IT WAS NECESSARY TO DEVELOP A TRAINING RESOURCE DATA BASE WHICH, AS A "BONUS" FOR THE USER, ALSO SERVES AS A STAND-ALONE INFORMATION SYSTEM. THE MODEL WILL PROVIDE MANAGERS WITH AN INCREASED LEVEL OF INFORMATION AND THE UNIQUE CAPABILITY OF ANALYZING ALTERNATE STRATEGIES BEFORE MAKING A DECISION CONCERNING COURSE CONVENINGS AND/OR THE UTILIZATION OF RESOURCES.

LINEAR PROGRAMMING IS EMPLOYED IN ARRIVING AT A DETERMINISTIC SOLUTION. AN IBM PROGRAM, MATHEMATICAL PROGRAMMING SYSTEM EXTENDED (MPSX), IS USED TO MAXIMIZE THE OBJECTIVE FUNCTION REFLECTING STUDENT THROUGHPUT. MPSX USES THE BONDED VARIABLE/PRODUCT FORM OF THE INVERSE/REVISED SIMPLEX METHOD.

THE CONSTRAINING EQUATIONS, WHICH REPRESENT RESOURCE LIMITS, ARE KEY IN FORMULATING A REALISTIC APPLICATION OF THE MODEL. SINCE ONLY A LIMITED GROUP OF INSTRUCTORS ARE QUALIFIED TO TEACH EACH TRAINING COURSE, THE SUM TOTAL OF THE INSTRUCTORS' TIME AVAILABLE FOR CLASSROOM INSTRUCTION LIMITS THE FREQUENCY OF COURSE CONVENINGS. SIMILARLY, THE CLASSROOM/LABORATORY SPACE IS LIMITED AND THIS PROVIDES AN ADDITIONAL CONSTRAINT. ALSO, MANY COURSES MUST BE CONVENED SOME MINIMUM NUMBER OF TIMES ANNUALLY TO FULFILL A MINIMUM TRAINING REQUIREMENT; THIS FURTHER BOUNDS THE SOLUTION.

THE PREDICTIVE CAPABILITIES OF THE SCRR MODEL ARE ENHANCED BY THE ABILITY TO MODIFY THE TRAINING RESOURCE DATA BASE AND OBSERVE THE IMPACT OF THE MODIFICATION. THIS CAPABILITY ENABLES THE TRAINING MANAGER TO PLAY "WHAT IF" GAMES WITH THE MODEL. SOME OF THE MODIFICATIONS THAT COULD BE MADE TO THE DATA BASE TO STUDY THE EFFECT OF THE CHANGE ARE AS FOLLOWS:

- A. COURSES ADDED OR DELETED.
- B. COURSE LENGTHS INCREASED OR DECREASED.
- C. COURSE FREQUENCY ALTERED.
- D. STUDENT/INSTRUCTOR RATIOS CHANGED.
- E. INCREASE OR DECREASE IN AVAILABILITY OF CLASSROOMS, LABORATORIES AND TRAINING DEVICES.
- F. INSTRUCTORS ADDED OR DELETED.
- G. INSTRUCTOR QUALIFICATIONS INCREASED.
- H. INSTRUCTOR AVAILABILITY CHANGED.

SYSTEM CAPABILITIES/REQUIREMENTS AND RESOURCE (SCRR) MODEL (Continued)

DATA BASE ITEM MODIFICATION, AS DESCRIBED ABOVE, AFFORD THE TRAINING MANAGER THE OPPORTUNITY TO DELETE OR VARY MANY KEY PARAMETERS. THIS TYPE OF MANIPULATION COULD NOT BE EASILY ACCOMPLISHED MANUALLY. THE TRAINING RESOURCE DATA BASE AND THE OPTIMIZATION FEATURES OF THE SCRR MODEL COUPLE TO OFFER THE TRAINING MANAGER A POWERFUL TOOL FOR BOTH PLANNING AND OPERATION AND, AS A MINIMUM, STRUCTURES THE RESOURCE PROBLEM FOR FURTHER ANALYSIS.

## EDUCATIONAL TECHNOLOGY EVALUATION (ETE) MODEL

THE ETE MODEL SIMULATES THE FLOW OF STUDENTS THROUGH A SELF-PACED, INDIVIDUALIZED LEARNING SYSTEM. THE MODEL WILL PROJECT SYSTEM OUTPUT, AVERAGE TIME-TO-COMPLETE AND INSTRUCTOR AND FACILITY UTILIZATION. IBM'S GENERAL PURPOSE SIMULATION SYSTEM (GPSS) IS USED IN THE MODEL.

THE STRATEGY OF INDIVIDUALIZED INSTRUCTION COMPLICATES PLANNING FOR SUCH A SYSTEM BECAUSE STUDENTS CANNOT BE TREATED AS GROUPS OF INDIVIDUALS BEING TRAINED TOGETHER. JUST TRACKING STUDENTS IN AN INDIVIDUALIZED LEARNING ENVIRONMENT IS, IN ITSELF, NO SIMPLE TASK.

SOME OF THE QUESTIONS THAT THE MODEL CAN ANSWER ARE AS FOLLOWS:

- A. ARE THERE ENOUGH QUALIFIED INSTRUCTORS TO SUPPORT AN INDIVIDUALIZED LEARNING SYSTEM.?
- B. CAN ENOUGH CARRELS BE INSTALLED IN EXISTING CLASSROOM SPACE?
- C. WHAT WOULD BE THE IMPACT ON COURSE THROUGHPUT OF REMOVING ADMINISTRATIVE DUTIES FROM THE INSTRUCTOR?
- D. HOW WILL THE AVERAGE TIME-TO-COMPLETE THE SERIES OF MODULES COMPARE WITH TRADITIONAL COURSE LENGTH?
- E. WHAT IS THE PERCENT UTILIZATION FOR INSTRUCTORS AND FACILITIES?
- F. CAN ADDITIONAL MODULES BE ADDED TO THE COURSE WITHOUT BURDENING STAFF OR FACILITIES?
- G. IF COURSES ARE CONSOLIDATED, WHAT IS THE EXPECTED SYSTEM THROUGHPUT?

AT PRESENT, IT IS IMPOSSIBLE TO ANSWER THESE KINDS OF QUESTIONS THROUGH CONVENTIONAL METHODS. THEREFORE, THE ETE MODEL IS A VITAL LINK IN THE TRAINING SYSTEM DESIGN PROCESS.



DEPARTMENT OF THE NAVY  
COMMANDER TRAINING COMMAND  
U. S. ATLANTIC FLEET  
NORFOLK, VIRGINIA 23511

FF8-2/N3A:mc

3900

Ser 1191

08 SEP 1975

From: Commander Training Command, U. S. Atlantic Fleet  
To: Director, Branch Office, Navy Personnel Research and  
Development Center, Washington, DC 20374

Subj: Design of Training Systems (DOTS); recommendations  
concerning

1. The Test and Evaluation (T&E) of subject system conducted in June of 1975 had as its objective the demonstration of the applications of operations research and management science techniques in the training community. The test, in part, demonstrated the potential value of such assistance in the decision-making progress. However, full utilization and cost effectiveness of such a system was not clearly substantiated; evaluation of the system at Fleet Training Center, Norfolk confirmed this opinion. At that command, the data base has been found useful in providing internal management information. The mathematical models, however, have not been utilized by that command.

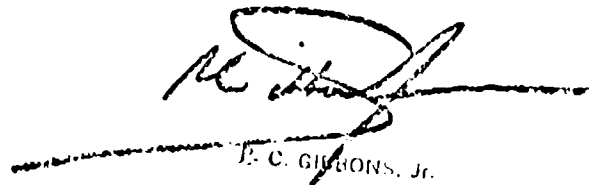
2. In view of the above, the following comments/recommendations are submitted:

a. Design of Training Systems (DOTS) has potential value for the training community and should be pursued further.

b. Development should remain in the Research and Development stage and the data base expanded sufficiently to permit evaluations of applicability and utility at higher levels than previously tested. Pursuant to this end, it is recommended that the test site be relocated from Fleet Training Center, Norfolk, to COMTRALANT Headquarters to facilitate experimentation and utility testing at the functional command level. It is also recommended that the data base be expanded to include all COMTRALANT activities and that access to the system be made available to the subordinate activities for both training and evaluation. Central siting, for the present, appears to be the only cost-effective manner in which to proceed.

c. While the value of DOTS as an independent system is understood, emphasis should be placed upon its incorporation into the NAVEDTRACOM data system with free exchange of ideas and information as a final goal on an open reciprocal basis.

d. CONTRAINT is prepared to participate in further experimentation and development of this system which, thus far, has demonstrated to a significant extent its potential value to the training community.



F. C. GIBBONS, Jr.

Code 015

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6 AUG 1975

From: Chief of Naval Technical Training  
To: Chief of Naval Education and Training

Subj: Design of Training Systems (DOTS)

Ref: (a) CNET ltr Code 01 of 14 May 1975

1. By reference (a), the Chief of Naval Education and Training requested that the Chief of Naval Technical Training submit an evaluation of the DOTS following the completion of the operational T & E (Test and Evaluation) at Fleet Training Center Norfolk.

2. The Chief of Naval Technical Training has weighed carefully the purposes, operational results, previous investment, and potential of the DOTS models. The following conclusions apply:

a. The T & E at Fleet Training Center Norfolk did not show the "substantiated proof of operational desirability, feasibility and economic acceptability" set forth as criteria in reference (a) to warrant tasking within the EDTRACOM for sponsorship, management, development and implementation.

b. The evaluation at Fleet Training Center Norfolk supports the earlier conclusion of the Chief of Naval Technical Training that the models have been primarily designed to help that level of management least requiring assistance in decision-making. This general conclusion was borne out by the Director of Training, Fleet Training Center, Norfolk, who indicated that use of the models for "what if" questions would be rare, and that his most frequent use was simply as a report-type reference (not the avowed province of the models). Although it is apparent that the System Capabilities/Requirements and Resources (SCRR) Model and the Training Process Flow (TPF) Model do have certain problem optimization capabilities and are workable at the schoolhouse level, it has not been demonstrated that these models would be extensively used or cost effective. It was in fact noted that an excellent and obvious opportunity to use the models to help solve a current practical problem (allocation of a staff allowance decrement) was not taken by the Fleet Training Center during the time of the T & E.

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c. Two specific technical deficiencies of the SCNR and TPF models were evident. These two models, both concerned with resultant impacts on training as a function of resource and demand variations are not interactive. They should be. This might well be a relatively simple programming change to effect, but the point is, as presently structured they are not. Secondly, and more importantly, the models are not iterative. While any one or more of the variables for a particular problem may be run and an optimal solution for that problem provided, the model(s) will not accommodate a reiterative matrix of the same variable and automatically optimize within the range of that matrix. For example, if we wanted to see what impact an X % decrease in facilities would have on training, the model would provide an answer; but if we wanted to know what maximum decrease in facilities we could accept within a range of X to Y % and still continue training, we would have to run the model for each and every number within that range. Even more significant is the fact that only by independent, single variable - change runs can the limiting or key variable in any problem be identified. Therefore multiple runs, separately initiated, must be made in which each variable is independently changed and whereupon the solution can therefore be accurately related to that specific variable.

d. In terms of functional-level use, the SCNR and TPF models as presently configured will not substantially assist the Chief of Naval Technical Training in either predicting/allocating resources or in assessing impact on student output of resource changes appreciably beyond the capability which now exists or is envisioned from NITRAS, SHORSTAMPS, RMS MCC and other systems. However, it is probable that higher-echelon variations of the SCNR and TPF could be developed.

e. It is considered that continuance of upward development aimed at eventually satisfying the above requirements is not justifiable solely by the fact that such development would be paid from R & D rather than operating funds. This is particularly true since it is anticipated that sufficient decision-making assistance will be available from other systems, and further redundancy of computer programs and products should be prevented.

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f. It is imperative that early efforts be made to define and coordinate those portions of other research and systems development efforts which appear to have objectives that are redundant to DOTS and to each other. Examples of these include STREPS, SEORSTAMPS, CENTRA, NITRAS, NATIS, MAPNIS, RACS, etc. This potential overlap will increase with the vertical evolution of SCRR and TPP to higher management levels.

g. The Educational Technology Evaluation (ETE) Model is, if nothing else, misnamed. It does not evaluate educational technology. It does simulate the flow of students through a self-paced, individualized training system and therefore provides a means of analyzing pipeline. This analytical capability is however, more predictive than prescriptive in that while it provides rapid analysis of cause and effect phenomena impacting upon a given system, it cannot in itself prescribe the one optimal configuration. This model also lacks an iterative capability.

3. In summary, the objective of the DOTS Project is "to improve the management of the Navy's Training system by providing an expanded decision-making capability for all levels of management...to be used by training managers in dealing with the various social and economic factors and with the technological advances that will impinge on Navy training through the 1980 decade." Although the SCRR, TPP and ETE models will fit within this broad objective statement, their utility has not been established. The value of the DOTS models at the schoolhouse level to assist or replace the on-site judgment of school managers remains questionable. Also, considerable evolution will be required to meet the objective "for all levels of management." This evolution would call for an extended period of R & D, and the results could be increasingly redundant with other models or systems unless some of the latter are eliminated.

#### 4. Recommendations:

a. That the DOTS project be terminated at the expiration of the current contract.

b. That upon completion of the current contract, the DOTS models, supporting software and documentation be provided to the NETISA for investigation as to their applicability and utility within extent EDTRACOM ADP systems.

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c. That a complete review and study of existing ADP systems within the EDTRACOM be conducted toward eliminating redundancy, duplication and competitive efforts.

UNCLASSIFIED

APPENDIX G

COMMENTS ON THE ANALYSIS OF STUDENT FAILURE RATES

## COMMENTS ON THE ANALYSIS OF STUDENT FAILURE RATES

Since "failure" in this study is a zero-one type variable, the analysis of possible relationships between failure or the failure rate and other student, class, or course characteristics raises some special problems. These can best be considered by first making a clear distinction between the "sampling unit" and the "prediction unit." In most regression analysis these are the same; here they may not be and, in fact, in the present analysis are not.

By "sampling unit" we mean the element from which data is originally collected. In this case it can either be the individual student or the group (class or course). In a similar way, the "prediction unit" can be either the individual or the group; we can either attempt to predict success or failure for the first (a zero-one variable) or the number or proportion of failures for the latter (the failure rate).

Using these criteria we can distinguish three different cases:<sup>1</sup>

Case I      Sampling and prediction unit - the individual student.

Case II     Sampling and prediction unit - the group.

Case III    Sampling unit - the individual student;  
             prediction unit - the group.

Case I    Sampling and prediction unit - the individual student.

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<sup>1</sup>In general we can aggregate for purposes of prediction but not disaggregate. Thus, a fourth case, group sampling and individual prediction is not considered. It would, however, be possible to expand Case III to cover groups of different sizes. For example, we could use the class as sampling unit but predict failure rates for the course or school.

This case is the one referred to in the literature as Discriminant Analysis.<sup>2</sup> We assume that the population of students can be dichotomized into two disjoint sub-populations, successes and failures. For each sub-population it is assumed that a multivariate distribution of predictor variables exists and that these distributions differ only in their vector of expected values. In the usual case it is assumed that the distributions are multivariate Normal with the same variance-covariance matrix.

Discriminant Analysis then consists of an attempt to find a linear "discriminant function" which creates two half-spaces associated with successes and failures in such a way that it minimizes the probability of misclassification. In this case the prediction is simply "success" or "failure" for the individual student. It should be noted that this approach assumes "failures" are qualitatively different and not just those students below a given quantitative cutoff.

Case II Sampling and prediction unit - the group.

The dependent variable in Case II is either the number or the proportion of students in the group who fail. This in some cases may be a Binomially distributed variable but the possibility of a more complex underlying probability process cannot be completely ignored. On the other hand, if the group size is larger, the distribution of the proportion of failures (the failure rate) will in many cases be approximately Normal.<sup>3</sup>

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<sup>2</sup>For example, see Guilford, J. D. Psychometric Methods, McGraw-Hill, 1954, P 364-365.

<sup>3</sup>The critical Assumption would seem to be whether or not individuals in the group succeed or fail independently. Intra-sample correlation can have a critical impact on the validity of the Central Limit Theorem.

The independent variables will be characteristics of the group rather than of the individual. This does not preclude the use of group collective measures such as mean GCT or its standard deviation. For Case II, the most critical problem relates to the assumption of homoskedasticity necessary for the usual use of regression analysis. If we assume that the dependent variable follows the Binomial distribution, it follows that both its variance and expected value will depend on the prediction variables. In this case it is possible to transform the independent variable so that the assumptions hold.<sup>4</sup> In the more general case the transformation may be more difficult to develop.

Case III Sampling unit - the individual student; prediction unit - the group

For the mixed case represented here, a number of very difficult problems arise. These can best be illustrated by considering a simple model with one predictor variable. Figure 1 illustrates the nature of the data for individual students. It can be seen that most of the assumptions associated with regression analysis are either incorrect or untestable. Linearity of the underlying model is unlikely since the relationship will be asymptotic at both zero and one. The errors are not normally distributed; for a given value of  $x$  they may be binomial. It follows that, as in Case II, the variance is a function of  $x$ . While the F test is known to be reasonably robust, it is not at all clear that it can be applied here.

Additional problems arise in using this model to predict failure rates for groups. First, as noted under Case II, there may be intraclass correlation so that the failure rate for the class will be different than the average failure probability of the members. More critical is the use of the group average of the  $x$  variable as an input to the model. It is at this point that the assumption of linearity in the model may become a major problem.

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<sup>4</sup>See material on Probit Analysis in J. D. Finney, Probit Analysis (2nd ed.), Cambridge University Press (1962).

As a simple example, assume  $x$  is perfectly correlated with the course grade so that there is some critical value of  $x$  (say  $x_c$ ) and all students below  $x_c$  fail. A possible distribution of  $x$  is shown in Figure 2a. It can be seen that increasing  $\bar{x}$  (shifting the distribution to the right) will decrease the proportion of failures in a non-linear way. In fact, if the distribution of  $x$  is normal, failure rates around 11%, as used in the report, are close to the point of maximum curvature of the function.

Because of this non-linearity,  $\bar{x}$  does not adequately summarize the distribution of  $x$ 's in the group. For example, in Figure 2b equal numbers of additional students are added to the group above and below  $\bar{x}$ .  $\bar{x}$  is not changed but the failure rate is substantially increased.

#### Summary

The problems associated with estimating group failure rates from data on individual students suggests that a more practical approach might be to work directly from group failure rates for classes. (That is to use the class as the sampling unit.) Even here some transformation such as the "probit" will be necessary to remove hetroskedasticity. Problems of aggregating class failure rates into course or school aggregates will still cause some problems, but appear much more tractable than the approach used previously.

R. E. W.

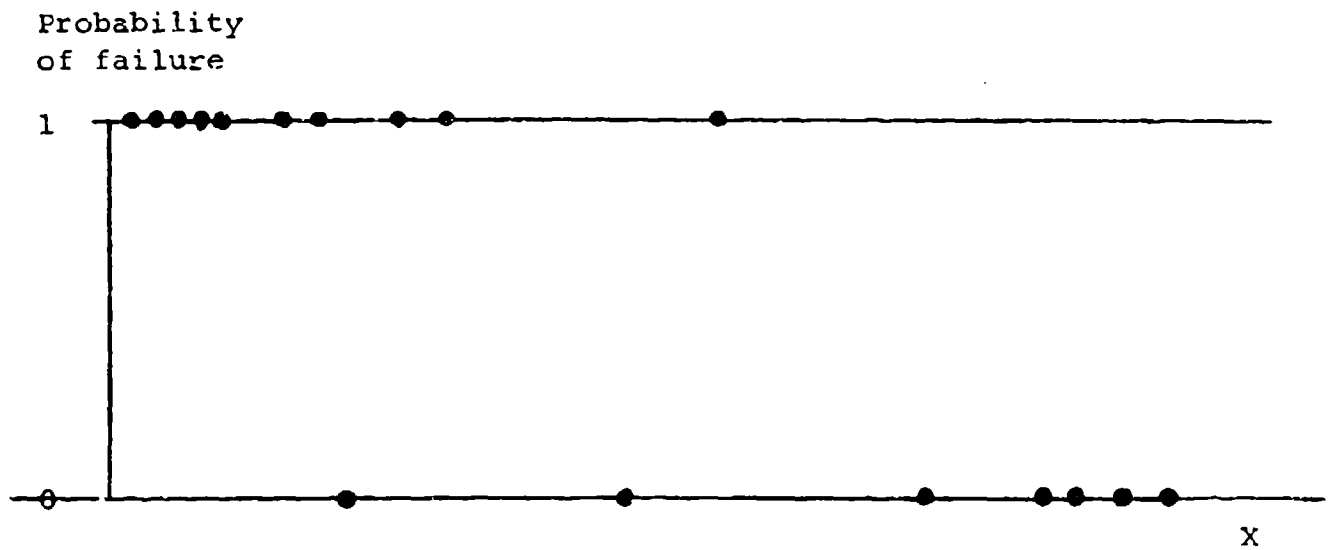


Figure 1: Illustration Sample Data for Individual Students

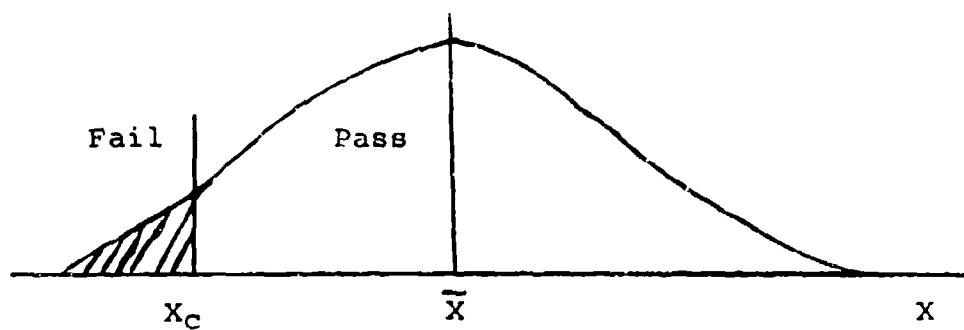


Figure 2a

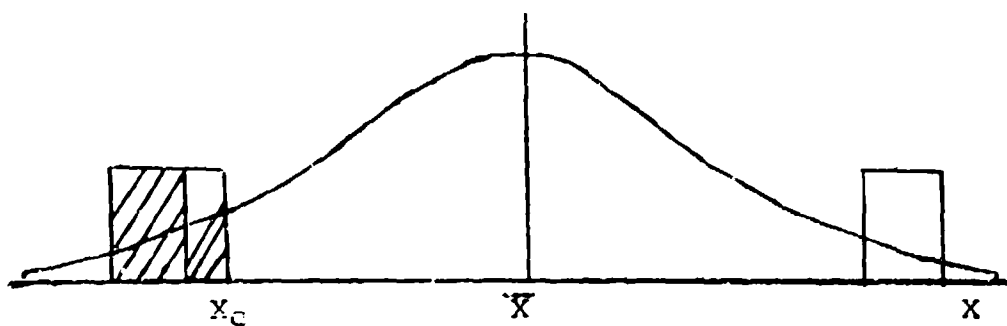


Figure 2b

APPENDIX H

PERTINENT INSTRUCTIONS

H-0

## PERTINENT INSTRUCTIONS

### SECNAVINST 5231.1

#### OPNAVINST 5231.1

Sets forth procedures for the Automated Data Systems Development (ADS); documentation and procedures for management.

### OPNAVINST 10462.8

Sets forth standards for higher level languages.

### SECNAVINST 5233. (varies)

Sets forth standards for documentation.

### SECNAVINST 11120.1 (series)

Describes telecommunication requirements.

### SECNAVINST 7000.14

Procedures for economic analysis in ADS.

### SECNAVINST 4860.44

Used when a comparison is to be made between "best in-house alternative" and a "commercial contractor alternative".

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